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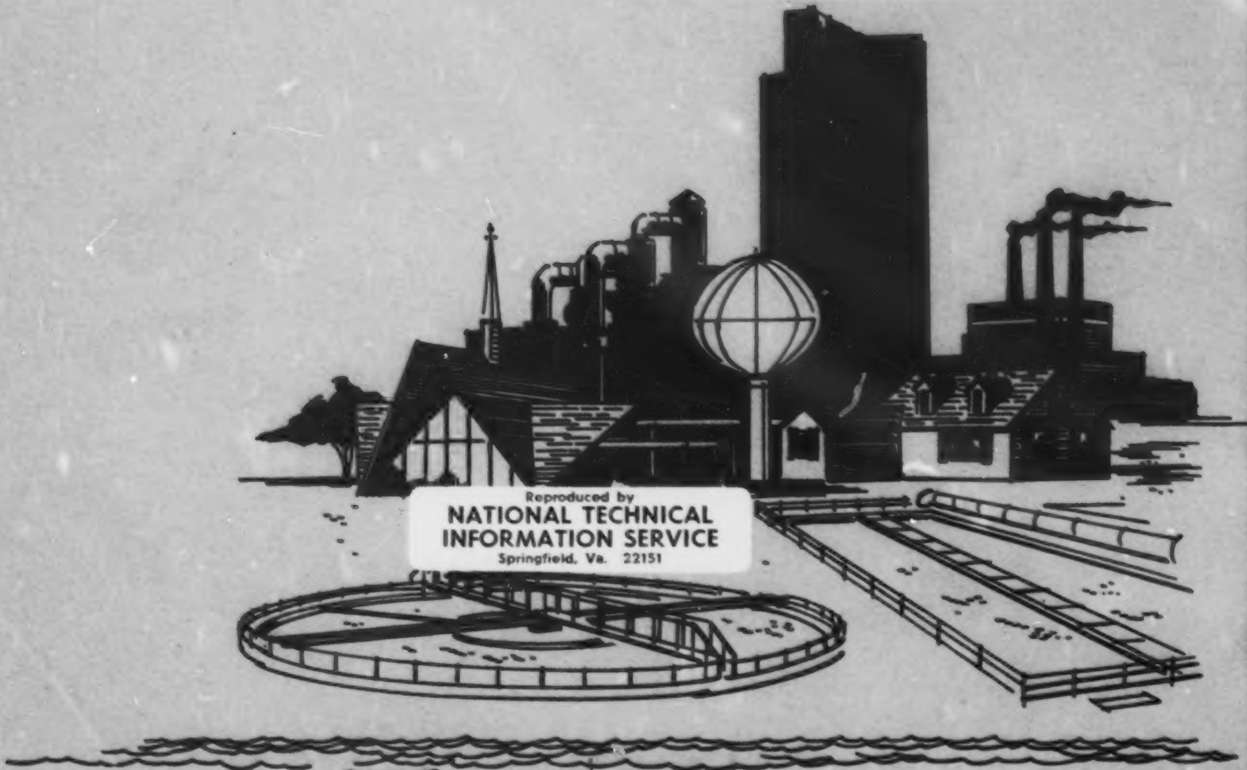
Biological Treatment of Chlorophenolic Wastes



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16. Abstract Biological degradation of a complex waste associated with the manufacture of herbicides, specifically 2,4-D, 2,4,5-T, and 2,4,5-TP acids, was accomplished under actual field conditions. A completely stirred aeration lagoon was installed between an existing conventional sewage treatment plant and existing stabilization lagoons to avoid hydraulic overloading of the former and reduce the BOD loading to the latter. Joint treatment of the herbicide waste and diluting municipal wastes was accomplished biologically, demonstrating that pilot plant studies related to such wastes reported in other literature are valid. Following construction and operation of the joint treatment system, complaints regarding taste and odor in fish and of the receiving waters have not recurred, although analytical data indicated a level of phenolics somewhat above the threshold values reported in the literature. The biological information gathered in this study indicates that conditions prevailing in the joint treatment system do not differ in any significant way from those to be expected in a similar system that does not receive complex chlorophenolic wastes combined with the normal sewage. In Vitro experiments with individual chlorophenols and the related chlorophenoxy acids diluted with aeration lagoon effluent indicated that these substances are rapidly decomposed when sufficient biological populations have been established. (Lowry-Texas)

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Abstractor Mark Lowry

Institution Texas University, Austin

BIOLOGICAL TREATMENT OF CHLOROPHENOLIC WASTES

The Demonstration of a Facility for the Biological Treatment of a Complex Chlorophenolic Waste.

by

The City of Jacksonville, Arkansas
Jacksonville, Arkansas 72076

for the

WATER QUALITY OFFICE,
ENVIRONMENTAL PROTECTION AGENCY

PROJECT NO. 12130 EGK
(formerly No. 11060 EGK)

June, 1971

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EPA Review Notice

This report has been reviewed by the Environmental Protection Agency and approved for publication. Approval does not signify that the contents necessarily reflect views and policies of the Environmental Protection Agency.

ABSTRACT

Installation of a completely stirred aeration lagoon between an existing conventional sewage treatment plant and existing stabilization ponds avoided hydraulic overloading of the former and reduced BOD loading of the latter. Joint treatment of domestic sewage and an industrial waste having high BOD and chlorophenols was facilitated. The study confirmed earlier findings that the organisms present in domestic sewage readily destroy complex chlorophenols and related materials. Glycolates and acetates contributing to the high BOD of the industrial waste were also readily oxidized biologically. High sodium chloride levels in the treated mixed waste did not adversely effect biological activity. Joint treatment of the complex chlorophenolic wastes combined with normal sewage gave rise to biolgical data which did not differ in any significant manner from that to be expected in a similar system receiving only normal sewage.

An historical background of the problem at Jacksonville, Arkansas; design and construction information, and the chemical and biological data resulting from the system study are presented.

This report was submitted in partial fulfillment of Project No. 12130 EGK between the Water Quality Office, Evnironmental Protection Agency and the City of Jacksonville, Arkansas.

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SECTION I

CONCLUSIONS

Biological degradation of the complex waste associated with the manufacture of herbicides, specifically 2,4-D, 2,4,5-T and 2,4,5-TP acids, may be accomplished under actual field conditions of operation of a sewage treatment plant with the proper dilution obtained by joint treatment. This project demonstrated that the pilot plant studies related to such wastes reported in other literature are valid.

Following new construction and operation of the joint treatment system, complaints regarding taste and odor in fish and of the receiving stream have not occurred, although analytical data indicated a level of phenolics somewhat above the threshold values reported in the literature.

The biological information gathered in this study indicates that conditions prevailing in the joint treatment system do not differ in any significant way from those to be expected in a similar system that does not receive complex chlorophenolic wastes combined with the normal sewage.

In vitro experiments with individual chlorophenols and the related chlorophenoxy acids diluted with aeration lagoon effluent indicated that these substances are rapidly decomposed when sufficient biological population has been developed. Obviously the nutrient requirements for good bacterial growth must have been met by the aeration lagoon mixture.

SECTION II

RECOMMENDATIONS

Although the industrial plant manufacturing phenoxyalkanoic herbicides did not operate continuously during the period of this study, for reasons beyond our control, the information and data provided is valid, if somewhat incomplete in some respects. It would have been more satisfactory to have had all operating conditions nearly constant throughout the study period.

Further research into the biological and chemical characteristics of the system would be desirable. Neither time nor personnel permitted isolation of the bacterial strains responsible for the apparent ring-opening of the chlorinated phenolics and derivatives or chemical determination of the specific breakdown products.

It is suggested that in future studies of chemicals which show refractory or poor biological degradation when mixed with biota of normal sewage, that they be carefully examined by means of prolonged in vitro methods to permit development of bacterial strains capable of their rapid destruction by metabolic or enzymatic destruction.

SECTION III

INTRODUCTION

The City of Jacksonville, Arkansas, typical of many rapidly developing communities in the southern United States, faced a serious problem at one of its two sewage disposal plants. This situation resulted in part because of population growth and in part because an industry discharged a waste having a high biochemical oxygen demand (BOD), including a portion of chlorophenolics related to herbicidal manufacture.

The results of a special survey in the upper Bayou Meto basin, conducted by the Arkansas Pollution Control Commission in 1967 led to the conclusion that the West Sewage Treatment system of Jacksonville was both hydraulically and organically overloaded. It therefore was stipulated that there should be no new industrial waste, or industrial expansion with accompanying increase in organic waste material or other toxic substances which could further upset the system.

The industry involved was requested to take further measures to reduce to a minimum the output of chlorophenolic materials in their process waste water, thereby reducing the possibility of toxic materials being discharged to Bayou Meto from the sewage treatment system.

Accordingly, a proposal designed to relieve the organic overloading of Bayou Meto and to improve the removal of chlorophenolics prior to discharge to the receiving stream was developed by consulting engineers retained by the City of Jacksonville. This proposal consisted essentially in providing an aeration basin in addition to the existing West Treatment Plant facilities. It was proposed that the aeration basin be located so as to permit aeration of the total flow in the system following treatment of a part of the total flow through the existing conventional treatment plant. Thereby hydraulic overloading of the existing plant could be avoided, but the combined treated and untreated portions could then be aerated before discharge to the existing stabilization ponds which discharge to Bayou Meto the receiving stream. The aeration step was predicated on the assumption that it would promote the bacterial degradation of the chlorophenolic industrial waste, based on published articles (1,2,3,6) and private communications (4,5).

Purpose and Scope:

The purpose of this project was to finalize the design, construction, and operation for joint treatment of an industrial waste together with a municipal waste; to study the biological and chemical effects of the treatment, and to provide hydraulic data which would permit evaluation of the joint treatment.

The scope of the design, construction, and operation work was intended to permit the demonstration of the process of joint treatment of an industrial herbicidal waste in conjunction with a municipal waste by a biological treatment system under full scale operation of the Jacksonville West Sewage Treatment Plant. The adequacy of nutrients from the domestic waste on the bio-degradation of the industrial waste was to be determined and optimized with due consideration of peak hydraulic loads. Also, the efficiency and feasibility of the overall system for effective treatment and control of chlorophenoxy herbicide concentrations of receiving waters was to be established.

The biological study was to include investigations of the factors which influence the removal of chlorophenolics by the biological system, and a study of the organisms in various parts of the treatment system and receiving waters.

The chemical study was to include the choice of suitable methods for the identification and determination of the various chlorophenolics encountered and where feasible to apply the methods to determine the relative rates of biochemical degradation.

The hydraulic study was to obtain necessary quantity and quality data of the various waste sources flowing into the West Treatment Plant as well as the effluent from the industrial plant and the waste waters within the plant, to permit evaluation of the project.

The overall project study was to permit evaluation of the feasibility and performance of the joint treatment of herbicidal-domestic wastes, and pollution abatement of receiving waters, as a result of the project actions and the treatment system used during the period of the project.

Historical Background:

In 1961 the City of Jacksonville, Arkansas, improved their existing West Sewage Treatment Plant. At that time, in addition to rehabilitation of the pumping station and clarigesters, a new secondary digester was added, with sludge drying beds and gas heating equipment, and 44 acres of stabilization ponds were provided.

Generally, these facilities were designed to serve a projected equivalent population of 17,800 persons; estimated to consist of 10,300 persons on the Little Rock Air Force Base and 7,500 persons in the City. The design was for an average daily flow of 1.78 million gallons per day (MGD), with a maximum installed pump capacity of 4.8 MGD to the plant, and 6.8 MGD to the ponds.

The organic load used in the design of those existing sewage treatment facilities was 3,560 pounds of 5-day biochemical oxygen demand (BOD_5) per day. It was assumed that 63% would be removed in the conventional plant, or a total of 2,250 pounds per day, leaving 1,310 pounds per day in the influent to the stabilization ponds.

Since 1961 the waste from a plant manufacturing phenoxy-alkanoic herbicides in Jacksonville has been added to the west treatment plant. When the City of Jacksonville first considered accepting the waste from the plant for treatment in the municipal treatment facility, it was believed that the only objectionable qualities in the industrial waste were its low pH and its chlorophenolic content. It was not anticipated at that time that the industrial waste would also be high in organic loading. The plant installed facilities for neutralizing the acidity of the industrial waste and the City of Jacksonville then accepted the waste for treatment in the municipal treatment system. The industrial waste water, neutralized to pH 7.2, was added to the City sewer at a low rate of flow on August 18, 1964, reaching the full plant effluent flow on October 1, 1964 by gradually increasing rates during that period.

Prior to this arrangement for treating the industrial waste, commercial fishermen and residents along Bayou Meto had frequently complained of odors in Bayou Meto, odd odors and taste in fish, and also of occasional fish kills in the stream. After the City had accepted the industrial waste for treatment in the municipal plant, these complaints continued, though reduced in number, resulting in a special survey in the Upper Bayou Meto Basin by the Arkansas Pollution Control Commission in the first half of 1967. This special survey indicated that the average sewage flow reaching the Jacksonville West Treatment Plant in June, 1967 was 2.4 MGD, containing a BOD_5 of 372 mg/l. Thus, the total BOD_5 in the sewage treatment plant (STP) influent was 7,650 pounds per day.

The survey further indicated that the existing clarigester-roughing filter treatment plant was removing only approximately 1,968 pounds of BOD_5 per day, with 5,682 pounds per day going to the 44 acres of stabilization pond. This represented a loading on the existing ponds of approximately 130 pounds of BOD_5 per acre per day. Such a loading exceeded the level recommended by the Arkansas State Department of Health by 100 pounds BOD_5 per acre per day.

In spite of this tremendous overload, the City's sewage treatment facilities were producing a reasonably satisfactory effluent in June, 1967. The average BOD_5 in the effluent from the stabilization ponds was 55 mg/l, including the oxygen demand of the algae content of the effluent. The average total phenol content of the influent to the ponds was 6.2 mg/l during March and April, 1967 and also in June, 1967, as reported in the Special Survey of Bayou Meto. The pond effluent averaged 1.0 mg/l of total phenol during this period, representing a reduction of 85 percent across the ponds. However, spot checks of the phenolic content of the pond effluent earlier in the year, when algae growths in the ponds were materially less by reason of winter weather, indicated that in the winter little or no removal of phenolics was being accomplished.

Past complaints indicated that Bayou Meto might be one of the most polluted streams in Arkansas. Lawsuits by property owners along Bayou Meto below Jacksonville have occurred because of this alleged pollution. It was therefore imperative that any pollution occasioned by the effluent from the City's West Sewage Treatment facility be reduced to a minimum.

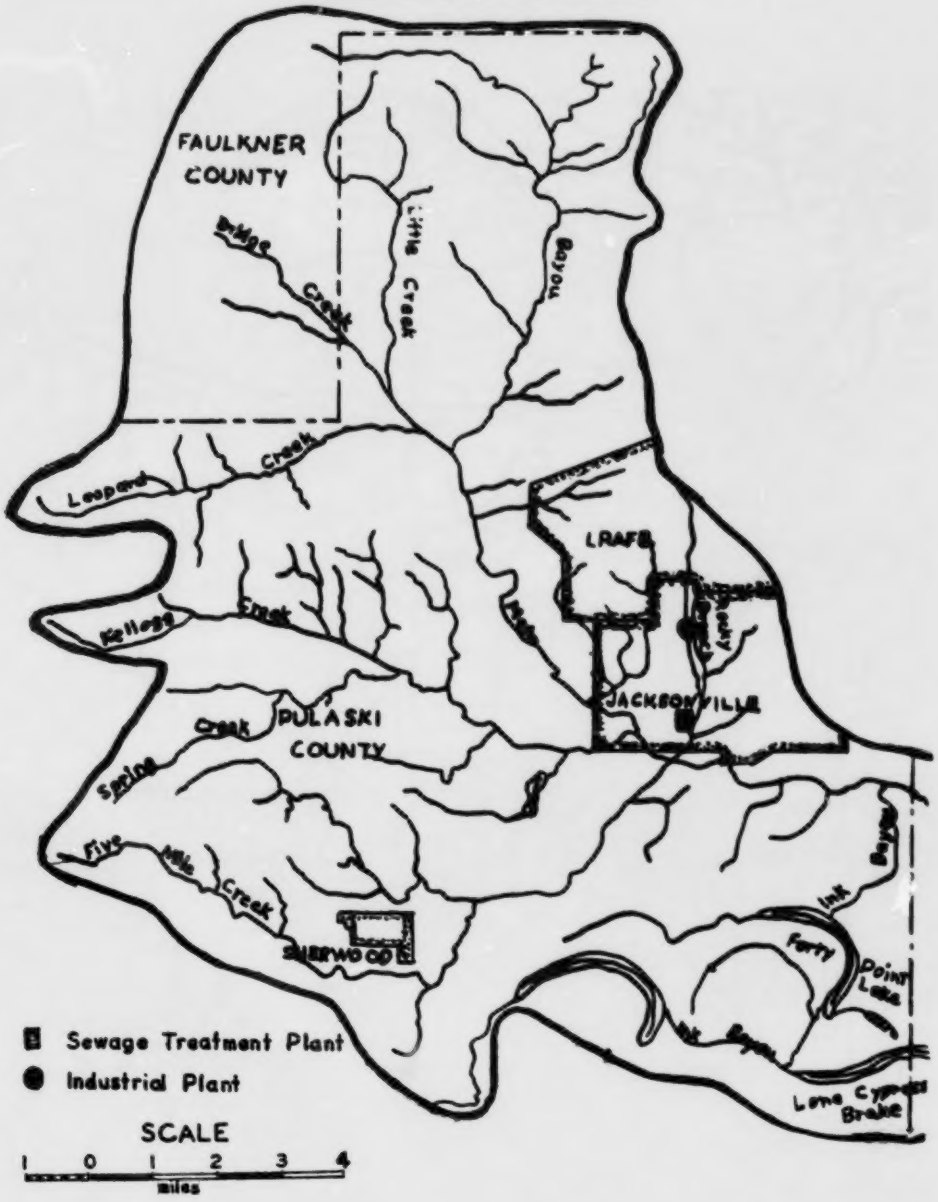
Bayou Meto

Bayou Meto, the receiving waters of effluent from the Jacksonville West STP, is a sluggish stream having a total drainage area of about 995 **square** miles at its mouth. Its headwaters lie generally northwest and west of Jacksonville, Arkansas, from which it flows meanderingly in a direction southeasterly through lowlands and farming country. It empties into the Arkansas River at a point about 10 miles northwest of Pendleton, Arkansas.

Map No. 1 shows the location of Jacksonville and the Little Rock Air Force Base in relation to the headwaters of Bayou Meto. Map No. 2 shows the extent and general location of the bayou in relation to the Arkansas River.

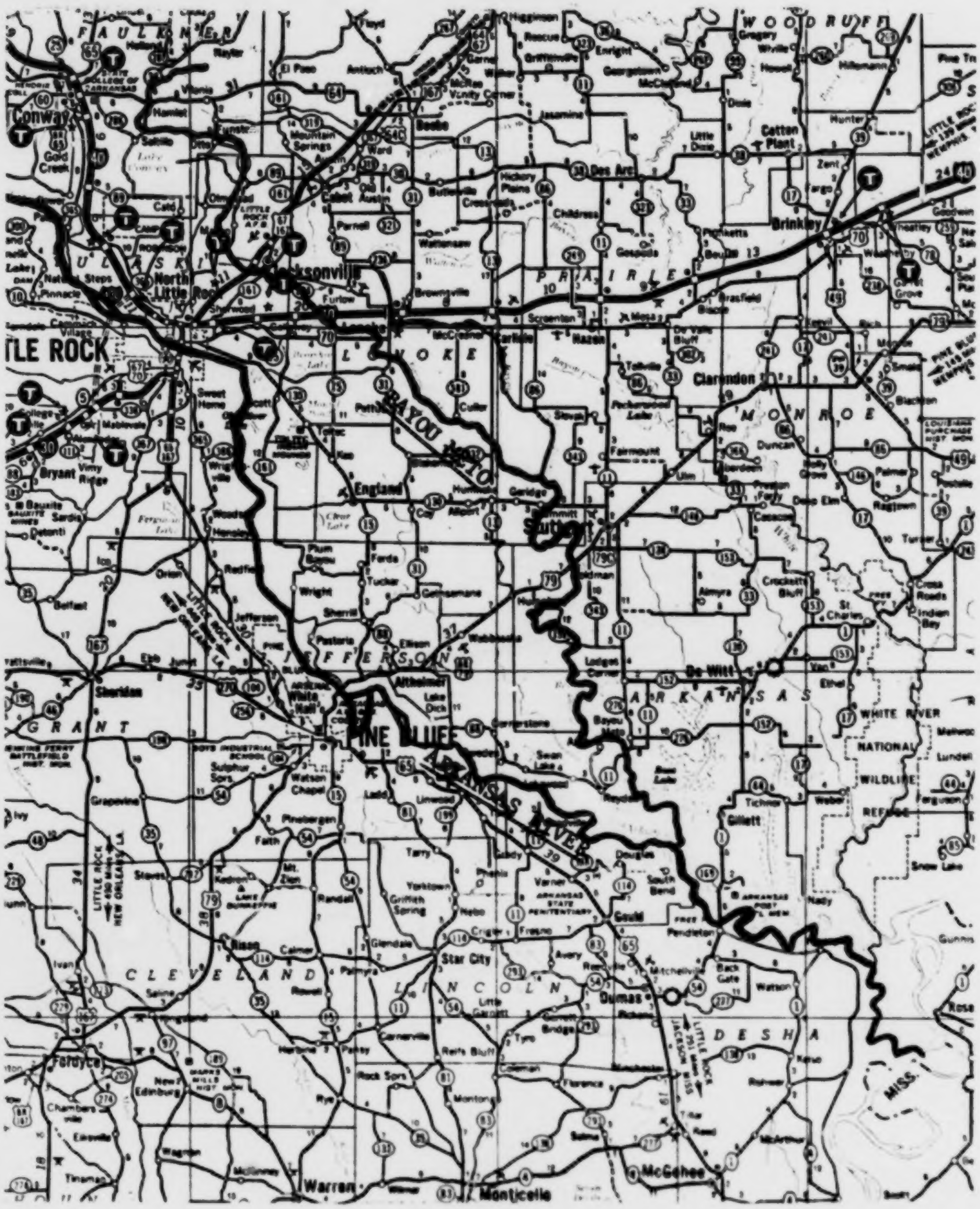
MAP NO. I

HEADWATERS OF BAYOU METO, ARKANSAS


FAULKNER COUNTY
Bridge Creek
Little Creek
Bayou
Leopard Creek
LRAFB
Kellogg Creek
Meto
Rocky
JACKSONVILLE
PULASKI COUNTY
Spring Creek
Five Mile Creek
SHERWOOD
Ink Bayou
Forty Point Lake
Bayou
Ink Bayou
Lone Cypress Brake
S Sewage Treatment Plant
● Industrial Plant
SCALE
1 0 1 2 3 4
miles

MAP NO. 2

BAYOU METO IN RELATION TO THE ARKANSAS RIVER


FAULKNER
WOODRUFF
Conway
PULASKI
LITTLE ROCK
North Little Rock
Jacksonville
LONOKE
PRAIRIE
MONROE
Brinkley
Clarendon
BAYOU METO
England
Stuttgart
JEFFERSON
PINE BLUFF
ARKANSAS
De Witt
ARKANSAS RIVER
GRANT
Sheridan
CLEVELAND
LINCOLN
Star City
DESHA
Dumas
McGehee
WHITE RIVER NATIONAL WILDLIFE REFUGE
Gillett
MISS.
Warren
Monticello
Fordyce

SECTION IV

DEVELOPMENT OF TREATMENT PROCESS

Development of Proposed Method of Treatment

In the special survey of the Upper Bayou Meto Basin by the Arkansas Pollution Control Commission, the average sewage flow reaching the Jacksonville West Treatment Plant in June, 1967 was 2.45 MGD, of which some 85,000 gallons was the flow from the industrial plant. The data presented in that report shows typical analyses of the combined flow reaching the City STP and of the industrial waste water, separately.

"TABLE I
TYPICAL CHEMICAL ANALYSES
JACKSONVILLE, ARKANSAS
June, 1967

		Combined Municipal and Industrial Waste	Industrial Waste
pH	ppm	7.2	7.3
Total Alkalinity	ppm	195	896
BOD	ppm	372	5,328
COD	ppm	543	6,768
Total Solids	ppm	3,286	83,610
Suspended Solids	ppm	171	762
Settleable Solids	ml/l	5.8	40
Chlorides	ppm	1,449	38,160
Phenol at pH 10	ppm	2.6	59.6
Phenol at pH 7.9	ppm	6.2	121.8
Flow at STP	MGD	2.47	
Flow from Plant	Gal.		85,000 "

The analyses presented then suggest that it would be extremely difficult to treat the industrial waste separately, but that when it is mixed with the municipal sewage the combined flow is susceptible to conventional treatment. Also, the analyses indicate that the problem of adequate treatment involves primarily removal of organic load as measured by 5-day biochemical oxygen demand and removal of phenols.

Simple phenolic wastes that are too dilute for practical recovery can be treated and the phenols decomposed by some form of oxidation. Aeration in the activated sludge process and oxidation in film flow biological oxidation systems (trickling filters), or as a combination of these two treatment processes, have been successful. On the basis of the literature cited, it was believed that the more complex chlorophenols, under properly controlled conditions, could also be removed by these methods. However, such conventional treatment methods are costly, both in initial construction cost and in operation and maintenance cost.

Experience with the combined wastes at Jacksonville during 1964-1967 indicated that the removal of phenols, including chlorophenols, can be effected most economically in surface aerated oxidation ponds. This experience also indicated that during winter months when algae activity in such lagoons is reduced, the removal of both BOD_5 and phenols is poor. These facts suggested that the most economical method for supplementary treatment of the combined wastes might be the installation of an aerated lagoon ahead of the existing two 22-acre stabilization ponds.

On the basis of then current knowledge of aerated lagoons, it appeared that the construction cost of a lagoon in the case of Jacksonville would be materially less than for conventional activated sludge or trickling filters, and that the annual operation and maintenance cost would be less.

As a result, it was proposed in early 1968 that the existing clarigester-filter plant be continued in service, treating a 1 MGD portion of the combined sewage flow at a uniform rate. This 1 MGD of treated sewage, together with all of the rest of the combined flow, would then be pumped to an aerated lagoon. After passing through the aerated lagoon, the effluent from that process would then flow into the existing 44-acres of stabilization ponds, which would in effect become finishing ponds. The effluent from the stabilization ponds would enter the receiving stream via an existing earthen ditch.

From the best information then available, it appeared that this plan would involve an aerated pond with an effective area of approximately three (3) acres. The pond contents would require complete stirring and provision of oxygenation capacity of about 745 pounds of oxygen per hour. This was estimated to be adequate for treatment of an applied BOD_5 of 9,650 pounds per day with a pond volume of 8.64 MG and an average influent of 2.88 MGD with a BOD_5 of about 400 mg/l.

This proposal was found acceptable by the Arkansas Pollution Control Commission and the Arkansas State Department of Health, and formed the basic process system of the present study.

DESIGN AND CONSTRUCTION

The design was finalized, plans and specifications were prepared, and construction was begun on November 4, 1968. No unanticipated problems arose during the construction period, which was essentially complete on May 7, 1969. The usual minor delays due to availability of specialized parts and equipment were not serious.

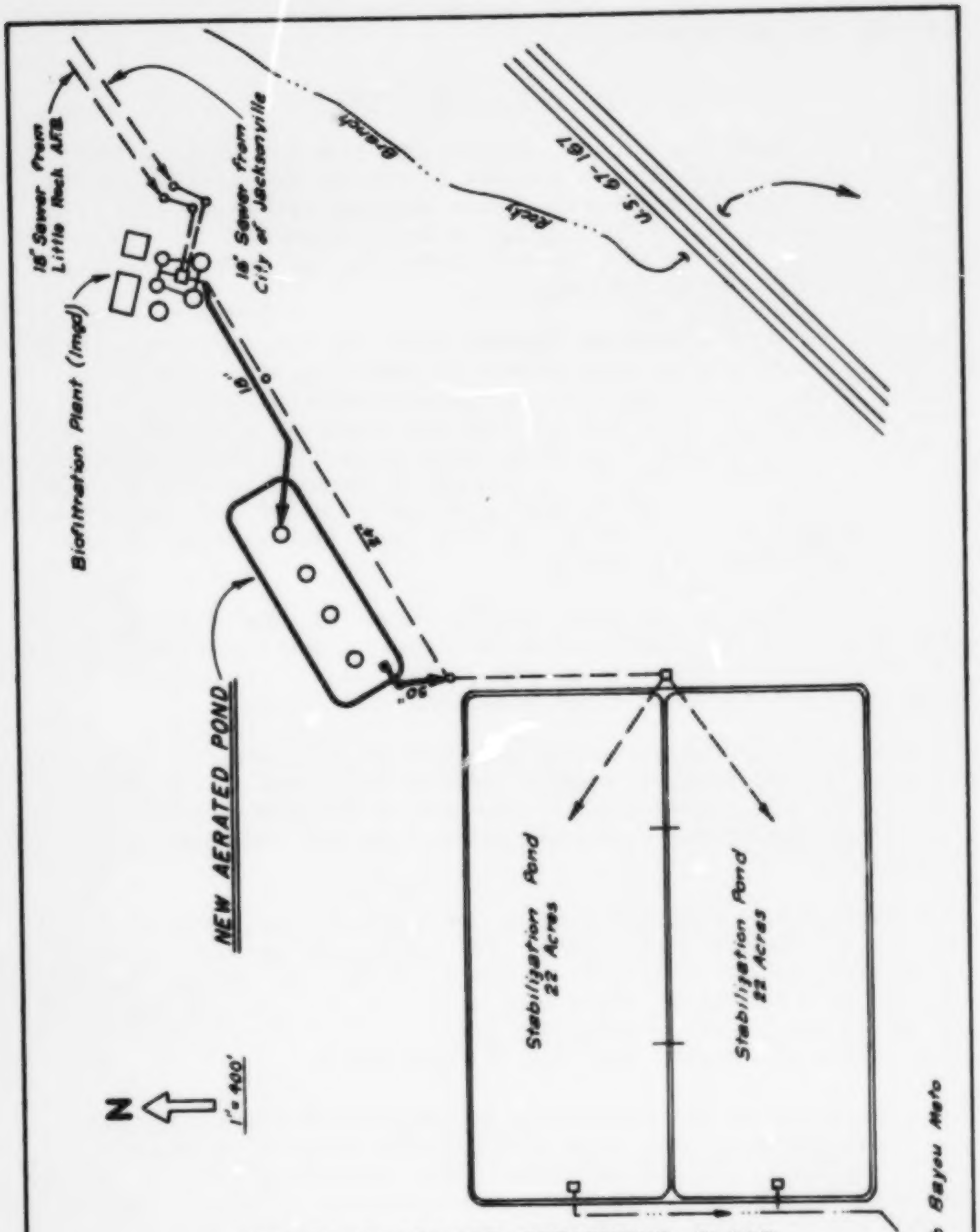
Details of the aeration lagoon and its relationship to the existing facilities are shown in Drawings No. 1 and 2. The lagoon has a capacity of approximately 8.4 MG, with a 3-day detention time at an average flow of 2.88 MGD. The bottom of the basin was excavated to a uniform grade to provide a normal operating depth of approximately 12 feet. Under normal conditions the average flow of 2.5 MGD results in a detention time of about 3.4 days and an operating depth of about 11.5 feet.

The upper section of the inside slope of the dike was surfaced with crushed stone to prevent soil erosion at the water's edge. The top of the dikes was surfaced to facilitate vehicular access around the basin.

Each of the 75 hp floating aerator units is held in position by three radial anchor cables attached to deadmen buried in the levee fill. One cable for each unit also supports the power service cable from the control panel to the motor.

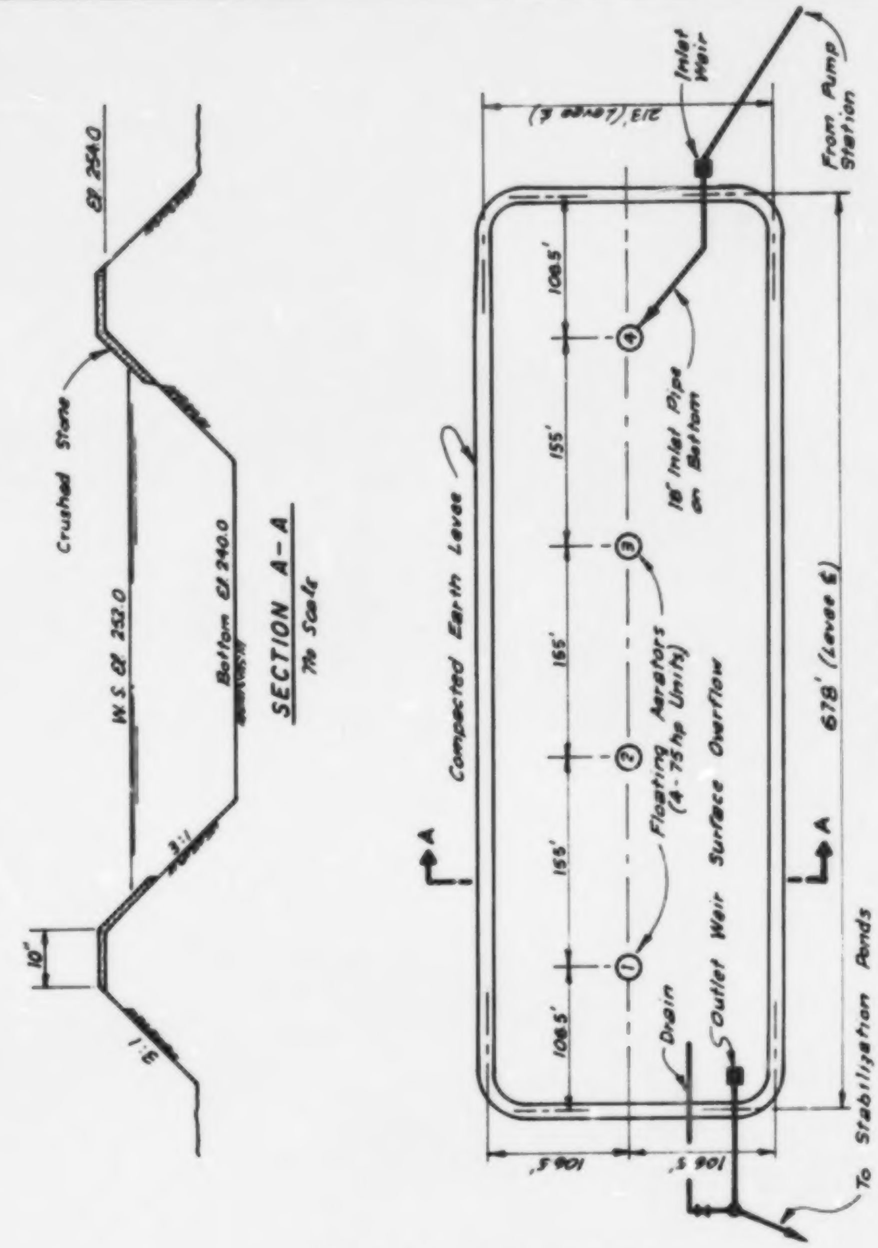
The aeration units each have the capacity to transfer 249 pounds of oxygen per hour. The combined design capacity is sufficient to transfer 23,900 pounds of oxygen per day, which is considered adequate to treat an applied BOD_5 load of at least 9,650 pounds per day with an excess of 2 mg/l of dissolved oxygen (DO) in the effluent.

Each aerator drive mechanism is supported by a circular, fiberglass, doughnut type raft consisting of a three-compartment circular pontoon. The rotating element turns within the circular pontoon and consists of a fabricated steel blade plate which carries 32 cupped blades, 8 feet in overall outside diameter. The oxygenation capacity of each aerator may be varied from a maximum of 249 pounds


18" Sewer from Little Rock AFB
18" Sewer from City of Jacksonville
Rocky Branch
U.S. 67-167
Biofiltration Plant (1mgd)
18"
24"
30"
NEW AERATED POND
Stabilization Pond 22 Acres
Stabilization Pond 22 Acres
N
1"=400'
To Bayou Meto

LAYOUT OF SEWAGE TREATMENT PLANT

DRAWING NO. 1



Crushed Stone
El 254.0
W.S. El 252.0
Bottom El 240.0
3:1
3:1
10'
SECTION A-A
No Scale
Compacted Earth Levee
108.5'
155'
155'
155'
108.5'
Floating Aerators (4-75hp Units)
16" Inlet Pipe on Bottom
Inlet Weir
From Pump Station
213' (Levee ℄)
106.5'
106.5'
678' (Levee ℄)
Drain
Outlet Weir Surface Overflow
To Stabilization Ponds
A
A
1
2
3
4
POND LAYOUT
1" = 100'

AERATED POND DETAILS
DRAWING NO.2

PHOTOGRAPH NO. 1
EMPTY LAGOON

PHOTOGRAPH NO. 2
FILLED LAGOON

per hour to a minimum of 166 pounds per hour by varying the submergence of the rotating blades. Submergence is controlled by ballast water within the hollow pontoon sections. Each drive unit is fitted with geared speed reducers to slow the speed of the rotating aeration element to a maximum of 37 RPM.

The four units have a pumping rate of 51,000 gallons per minute each, and when operating together can change the contents of the lagoon approximately every 41 minutes. The average velocity of liquid throughout the lagoon with four units in operation is about 0.5 foot per second.

The position of the aerators in the empty lagoon is shown in Photograph No. 1. Influent to the lagoon is on the bottom below aerator No. 4 in the foreground of the picture. Photograph No. 2 illustrates the filled lagoon with the four aeration units in operation.

Pumping Facilities:

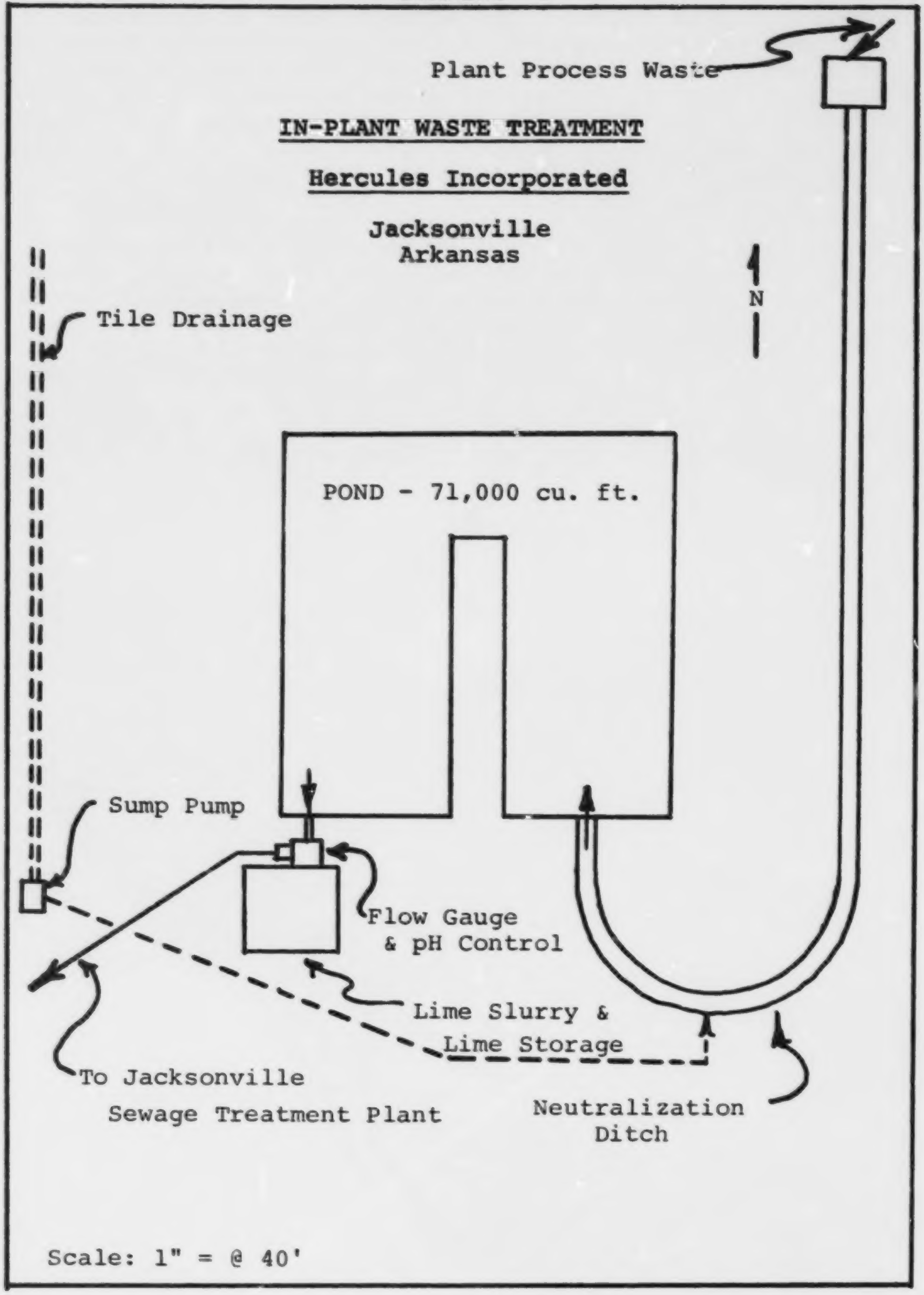
Sewage reaches the Jacksonville West STP via separate lines from a large part of the City of Jacksonville and from the Little Rock Air Force Base. These two lines terminate in a common underground wet-well located adjacent to the Jacksonville West STP pump house.

The combined sewage may be handled by four different pumps from the wet-well: One 700 gallons per minute (GPM) pump may be used continuously to feed the conventional sewage treatment system, which was designed for a flow of one MGD. Treated liquor from this system is returned continuously to the wet-well after passing over the rocks of the film flow biological oxidation section (trickling filters). Two 1,320 GPM pumps, piped in parallel, discharge into a 12-inch force main which connects to an 18-inch force main line leading directly to the inlet structure of the aeration basin. These pumps operate automatically, singly or together as required, to maintain a level in the wet-well for total flows up to about 3.8 MGD. For greater flows, one 2,570 GPM pump is piped separately from the wet-well to the 18-inch force main. This pump automatically cuts-in to handle flows in excess of 3.8-4.0 MGD.

Industrial Plant Pre-Treatment:

A schematic diagram of the industrial plant waste stream pre-treatment is shown in Drawing No. 3. The industrial plant waste is collected by an in-plant system of

DRAWING -3


Plant Process Waste
IN-PLANT WASTE TREATMENT
Hercules Incorporated
Jacksonville
Arkansas
N
Tile Drainage
POND - 71,000 cu. ft.
Sump Pump
Flow Gauge
& pH Control
Lime Slurry &
Lime Storage
To Jacksonville
Sewage Treatment Plant
Neutralization
Ditch
Scale: 1" = @ 40'

underground pipes with skimming sumps for removal of light or heavy liquid phases. The aqueous phase is processed through a crushed limestone filled neutralization ditch fabricated of acid resistant brick. The liquid passes through successive "piles" of limestone which serves to impede flow, permitting time for neutralization. Effluent from the ditch passes to the in-plant equalization pond at pH of about 5.3-5.8. The effluent from the equalization pond is further adjusted to pH 7.2 by automatic addition of slaked lime slurry in a continuously stirred pit. The neutral waste overflows to a rectangular settling pit or turbulence quieting section and thence over a weir, reaching the City sewer via a six-inch pipe. Measurement of pH is made within the liming pit for purposes of continuous record and control. The quantity of waste leaving the industrial plant is continuously measured by level in the quieting section ahead of the outlet weir.

SECTION V

HYDROLOGIC AND CLIMATIC DATA

Flow Measurements:

Total flow in the system was measured by a newly installed level recording device at the influent section of the aeration lagoon. This recorded the level of flow over a Cipoletti weir having a three (3) foot crest. The charts were changed daily and the flow in MGD was determined with the aid of a graph relating depth of flow over the weir to volume.

Flow from the stabilization ponds was measured by a newly installed level recording device at the outlet of Pond No. 1. Since the pond outlet weirs are at the same elevation and are as nearly identical as possible, the flow at the outlet of Pond No. 1 was doubled to obtain the total out-flow to a ditch leading to Bayou Meto, the receiving stream.

Flow from the Air Base was determined from an existing automatic level detector recording instantaneous flow in MGD and employing a seven day chart. This device was used to record flow through a Parshall flume located close to the wet-well, in the sewer line from the Air Base. Measurements with this flow meter were not wholly satisfactory. Calibration was difficult to maintain accurately. However, enough measurements were made available to indicate that the flow from the City and from the Air Base were practically equal during periods of dry weather.

Considerable infiltration of the sewer lines was noted during periods of heavy general rain. Most of this appeared to come through the City lines which are considerably older than those of the Air Base. Installation of the high capacity pump in the system, to keep the wet-well level below the flood point of the entering lines, made measurement of the relative separate flows more practical by visual observation.

Total flow through the aeration lagoon and from the stabilization ponds is presented in Table I. The data shown represents averaged flow for two week periods from May 16, 1969 through July 15, 1970.

TABLE I

AVERAGED FLOW DATA

Time Period	Aeration Basin Influent		Stabilization Ponds Effluent	
		DETN.*		DETN.*
May 16-31, 1969	2.24	13	2.82	16
June 1-15	1.97	11	1.91	15
June 16-30	2.30	13	2.57	14
July 1-15	1.95	14	1.84	7
July 16-31	2.45	16	2.03	15
August 1-15	2.12	15	1.47	15
August 16-31	2.40	14	2.13	12
September 1-15	2.13	14	1.52	15
September 16-30	2.09	13	1.51	15
October 1-15	2.45	11	1.57	8
October 16-31	2.45	9	--**	0
November 1-15	2.01	15	1.57	11
November 16-30	2.50	14	2.42	14
December 1-15	2.77	15	2.34	15
December 16-31	2.74	12	2.16	11
January 1-15, 1970	3.70	10	3.62	11
January 16-31	3.09	16	2.68	10
February 1-15	3.37	6	3.80	6
February 16-28	3.36	11	2.93	9
March 1-15	3.97	10	4.33	14
March 16-31	3.59	12	3.30	9
April 1-15	2.88	14	2.90	15
April 16-30	4.12	11	4.25	15
May 1-15	2.93	11	2.70	15
May 16-31	2.41	10	1.76	15
June 1-15	2.59	13	2.29	15
June 16-30	2.26	15	1.58	11
July 1-15	2.01	15	1.44	9

*DETN. - Number of days for which measurements were available.

**Stabilization Pond Recorder stolen on or about October 9, 1969 - Replaced November 3, 1969.

Weather Conditions:

A summary of the average air temperature and amount of rainfall during the period May, 1969 through August, 1970 is given in Table II. Dates and amounts of rain measured at the Little Rock Air Force Base weather station are reported in Table III.

Evaporative Effects:

It was not possible to determine effects of evaporation due to aeration. For practical reasons, the effluent volume was assumed to be identical to that of the influent.

The volume of effluent from the stabilization ponds was found to vary from the daily total flow in an understandable, but unpredictable way. The average volume leaving the ponds generally was less than the average volume of flow through the lagoon, but heavy rain readily reversed this behavior. Although there were indications of heavy infiltration of the sewer system, the rapid reaction of the ponds to heavy rain was due to simple entrapment by the 44 acre surface. This is to be expected when it is remembered that one inch of rainfall on 44 acres represents nearly 1.2 MG of volume.

During the summer months the ratio of volume leaving the ponds to that entering approached 70%, but there did not seem to be a practical way to separate concentration effects.

TABLE II

CLIMATOLOGICAL SUMMARY

May, 1969 - August, 1970

	Daily Temperature			Number	Total
Month	Mean Max.°F	Mean Min.°F	Range°F	Days Rain	Precipitation (Inches)
1969:					
May	80.7	59.1	42 - 88	10	4.60
June	86.6	66.9	47 - 97	7	4.34
July	94.7	76.5	68 -103	6	2.84
Aug.	88.7	66.8	59 -100	4	2.60
Sept.	83.9	62.5	51 - 93	5	2.02
Oct.	74.1	52.0	36 - 91	9	5.08
Nov.	60.4	36.5	20 - 72	5	3.81
Dec.	49.3	32.1	25 - 67	12	8.20
1970:					
Jan.	45.6	25.6	6 - 75	9	1.23
Feb.	52.2	32.2	13 - 70	11	4.21
March	56.4	39.3	26 - 75	12	5.76
April	74.8	57.9	32 - 84	12	8.58
					53.27
May	83.2	59.7	44 - 92	4	0.74
June	87.6	66.8	53 - 98	6	2.48
July	89.4	68.9	56 -101	7	2.88
Aug.	89.9	70.9	59 - 96	8	1.98

TABLE III

RAINFALL

May, 1969 - August, 1970

DATE	AMOUNT (Inches)
1969:	
May 4	0.40
7	0.64
8	0.07
11	0.02
12	0.18
17	2.32
18	0.23
24	0.18
28	0.05
29	0.51
	4.60
June 9	0.42
13	0.12
14	0.04
18	tr
20	0.24
21	1.52
23	1.09
24	0.91
	4.34
July 1	0.20
2	tr
13	0.20
19	0.14
24	1.06
25	0.04
26	tr
27	1.20
	2.84
Aug. 14	tr
15	tr
16	1.91
17	tr
18	0.01
20	tr
21	0.61
22	tr
31	0.07
	2.60
1969:	
Sept. 2	0.27
3	0.20
4	tr
7	0.04
16	0.53
23	0.98
	2.02
Oct. 6	1.32
10	0.32
11	0.39
12	0.14
13	0.92
25	0.02
29	0.03
30	1.84
31	0.10
	5.08
Nov. 2	0.09
3	tr
7	tr
11	0.07
13	tr
14	tr
16	tr
17	2.21
18	1.23
27	0.21
	3.81
Dec. 5	0.25
6	1.94
7	0.12
18	0.01
20	0.10
21	0.32
24	0.25
25	0.04
27	0.03
28	2.91
29	1.61
30	0.62
31	tr
	8.20
1970:	
Jan. 5	0.20
6	0.14
10	0.50
11	0.06
16	0.02
17	0.11
18	0.16
19	tr
20	0.01
21	0.03
28	tr
	1.23
Feb. 1	1.41
2	0.16
5	tr
6	0.10
8	0.13
14	0.52
15	1.17
22	0.12
23	0.06
24	0.15
25	0.10
28	0.29
	4.21
Mar. 1	0.09
2	0.87
3	1.23
4	0.01
7	tr
11	0.79
12	0.01
16	tr
17	1.52
18	tr
19	0.02
21	0.19
25	0.72
28	0.27
30	0.04
	5.76

TABLE III - Cont'd:

RAINFALL

May, 1969 - August, 1970

DATE	AMOUNT (Inches)	DATE	AMOUNT (Inches)	DATE	AMOUNT (Inches)
1970:		1970:		1970:	
Apr. 1	0.07	June 1	0.99	Aug. 2	0.45
5	0.01	2	0.46	5	tr
12	0.04	3	tr	7	0.84
15	0.01	4	0.04	9	0.33
16	0.42	6	tr	10	0.07
17	1.72	12	0.17	16	0.01
18	0.10	21	0.45	18	0.01
19	2.02	24	tr	20	tr
22	0.01	26	0.37	21	0.18
23	tr		2.48	22	0.09
24	0.97	July 7	tr	31	tr
25	1.43	8	0.51		1.98
27	tr	11	tr		
28	tr	15	1.89		
29	tr	16	0.18		
30	1.78	18	tr		
	8.58	20	0.01		
May 1	tr	21	tr		
9	tr	22	tr		
10	tr	23	0.11		
15	0.08	25	0.07		
16	tr	26	tr		
27	tr	27	0.11		
28	0.15	28	tr		
29	0.04	31	tr		
30	tr		2.88		
31	0.47				
	0.74				

SECTION VI

OPERATIONAL STUDIES

Upon completion of the major construction and installation of the aeration equipment, sewage flow was diverted from its prior path to the empty basin. The water level reached the level of the outlet weir within four days. At that time, final adjustment and check-out of the equipment was performed. Operation became routine immediately following acceptance of the completed work by the City's consultant engineers.

Operational difficulties have been at a minimum. For example, the ambient temperature within the electrical starter panel was high enough during the hot summer months of 1969 to permit tripping of the heater elements in the starters. This problem was eliminated by the addition of larger elements to the starters.

Only one major difficulty was encountered. This was the failure of the gear speed reducer in the Number 1 aerator, nearest the outlet end of the lagoon. This failure occurred after nine months of operation and required moving the aerator to the outlet end bank, with removal of the parts for shipment to the manufacturer for repair by the manufacturer under their warranty.

Access to the aerators for maintenance and cleaning was provided by a light weight rowboat which was stored upside down on the outer bank of the dike when not in use. When inspection or maintenance of the aerators was done, at least two persons were present as a safety precaution.

Each aerator was stopped for examination and maintenance on a routine basis. The aerator Number 4 located immediately above the end of the influent pipe required most attention. It required blade cleaning more frequently than the others because of build-up of adhering solids.

At the beginning of the study, greatest concern was with the behavior of the aeration lagoon.

It was noted immediately that BOD values of aeration lagoon influent samples were considerably lower than those reported in the Special Survey of Bayou Meto - 1967 for the raw waste reaching the Jacksonville West STP. This was believed to be due in part to the fact that the industrial plant had been operating at a greatly reduced level. Also, because a considerable portion of the raw sewage was routinely processed through the conventional STP, as planned in the proposed method of joint treatment.

Composition of Wet-Well Contents:

That portion of the total flow treated through the conventional system (1 MGD) originated in the wet-well which also feeds the aeration lagoon. The treated sewage was returned to the wet-well at an average rate of 1 MGD to mix with the incoming raw sewage. This returning treated stream thus diluted the incoming raw sewage, so that the strength of the feed to the conventional system and to the aeration lagoon normally would be less than that of the raw sewage.

In such a system, the fractional amount of the total flow treated per day equals the volume pumped to the conventional system divided by the total flow per day.

The degree of dilution of the biologically oxidizable contents (and separable solids) depends upon the total flow per day divided by the sum of the total flow per day plus the volume per day circulated through the conventional system.

$$F_C = \frac{Q_C}{Q_T} = \text{Fraction treated through conventional STP}$$

$$F_D = \frac{Q_T}{Q_T + Q_C} = \text{Dilution factor}$$

where Q_T = total flow in MGD

Q_C = constant flow to conventional STP in MGD

For a constant flow of 1 MGD through the conventional system and an assumed total flow of 2.5 MGD the fractional amount treated through the conventional system would be 1 MGD/2.5 MGD or 0.4 (40%). The dilution factor of the raw sewage in the wet-well would be 2.5 MGD/3.5 MGD or 0.714 (71.4%).

The strength of the wet-well contents, in this assumed instance, would be equal to the BOD_5 of the entering raw sewage times 0.714 plus 0.286 times the BOD_5 of the treated sewage stream returning to the wet-well from the filters of the conventional system.

$$\text{Wet-well BOD}_5 = F_D \times \text{Raw Sewage BOD}_5 + (1-F_D) \times \text{treated waste BOD}_5$$

Thus the average strength of the waste in the wet-well will be below that of the incoming waste stream if the conventional STP removes BOD effectively. It should be weakest for low total flows near the volume circulated, approaching incoming raw waste strength for exceedingly high total flows.

It was assumed that the chemical composition of the wet-well contents and that of the aeration lagoon influent would be nearly identical. The relatively short length of force main leading to the lagoon influent structure and the rate of flow favor this assumption.

A test of this assumption was made by means of grab samples taken nearly simultaneously from the wet-well and from the aeration lagoon influent well. Grab samples were necessary because no suitable equipment was available for sampling at the depths involved. The data obtained during late September and October, 1969, when the industrial waste flow was negligible, is shown in Tables IV and V.

It was found that the averaged values of BOD_5 of samples taken from the wet-well and from the aeration lagoon influent were 77.8 mg/l and 75.4 mg/l, respectively.

Samples of the filter effluent from the conventional system on its way to the wet-well were also taken during this same period. The averaged BOD_5 of the treated stream was found to be 21.4 mg/l, as shown in Table VI.

Although the reliability of grab samples should always be suspected, the average value of the wet-well BOD_5 and that of the filter effluent obtained during this period, when the average total flow was 2.45 MGD, gives an opportunity to estimate the probable averaged strength of the mixed raw sewage. Using the method outlined above to calculate the strength of the wet-well BOD_5, a mixed raw sewage having an assumed BOD_5 of 101 mg/l would account for the observed average value of 77.8 mg/l; the calculated value would be 77.9 mg/l.

TABLE IV

WET-WELL CONTENTS

West Jacksonville Sewage Treatment Plant

9/17 - 10/24,1969

DATE	BOD_5 mg/l	pH	DO mg/l	Temperature °C
9/17/69	80	6.9	0	-
9/18/69	102	6.9	0	-
9/19/69	95	6.9	0.5	-
9/26/69	95	7.1	0	-
10/1/69	62	7.3	0.3	-
10/2/69	135	7.4	0	-
10/3/69	63	7.2	0.2	-
10/6/69	70	7.6	0.4	-
10/8/69	54	7.4	0.3	-
10/9/69	70	7.0	0.9	-
10/10/69	63	7.0	0	-
10/13/69	43	6.9	0	-
10/15/69	76	7.1	1.1	-
10/16/69	64	7.2	1.0	22
10/17/69	72	7.1	0.5	22
10/20/69	104	7.3	0	23
10/22/69	68	7.3	0.4	20
10/23/69	76	7.2	0.3	21
10/24/69	86	7.1	0	21
Average:	77.8	7.15	0.3	21.5

(Average volume to Conventional STP - 1 MGD;

Average volume to Aeration Lagoon - 2.45 MGD.)

TABLE V

AERATION LAGOON INFLUENT

West Jacksonville Sewage Treatment Plant

9/17 - 10/24, 1969

DATE	BOD_5 mg/l	pH	DO mg/l	Temperature °C
9/17/69	72	7.0	0	-
9/18/69	110	6.9	0	-
9/19/69	111	7.0	0.2	-
9/26/69	97.5	7.2	0	-
10/1/69	72	7.9	0.7	-
10/2/69	120	7.1	0	-
10/3/69	53	7.3	0	-
10/6/69	60	7.3	0	-
10/8/69	40	7.5	0.4	-
10/9/69	58	7.7	0.3	-
10/10/69	62	7.3	0	-
10/13/69	65	7.0	0.6	-
10/15/69	58	7.6	0.5	-
10/16/69	67	7.5	0.3	22
10/17/69	51	7.4	0.2	22
10/20/69	94	7.3	0	23
10/22/69	80	7.4	0	22
10/23/69	70	7.2	0	21
10/24/69	93	7.3	0	21
Average:	75.4	7.3	0.17	21.8

(Average volume of influent - 2.45 MGD.)

TABLE VI

FILTER EFFLUENT

West Jacksonville Sewage Treatment Plant

9/17 - 10/24, 1969

DATE	BOD_5 mg/l	pH	DO mg/l	Temperature °C
9/17/69	10	7.3	4.5	-
9/18/69	18	7.3	4.9	-
9/19/69	21	7.3	5.5	-
9/26/69	18.5	7.3	5.1	-
10/2/69	24	7.2	5.2	-
10/3/69	18	7.2	5.1	-
10/6/69	19.5	7.3	4.5	-
10/8/69	16	7.2	5.2	24
10/9/69	29	7.2	5.1	-
10/10/69	30.5	7.3	3.8	24
10/13/69	19.5	7.2	5.4	23
10/15/69	17	7.4	5.1	22
10/16/69	17	7.3	5.9	20
10/17/69	19	7.3	5.4	20
10/20/69	24	7.4	4.7	22
10/22/69	26.5	7.4	5.7	22
10/23/69	29	7.3	5.8	19
10/24/69	28.5	7.3	5.9	19
Average	21.4	7.3	5.15	21.5

(Average volume from STP - 1 MGD;

Average total flow - 2.45 MGD.)

Determination of the chlorophenol and chlorophenoxyacid content of some of the samples yielded the following averages:

	Wet-Well	Filter Effluent
Chlorophenols, mg/l	0.33	0.15
Chlorophenoxyacids, mg/l	0.88	0.91

The apparent efficiency of the conventional system with respect to removal of BOD_5, chlorophenols and chlorophenoxyacids during the period was as follows:

BOD_5	72.5%	Removal
Chlorophenols	54.5%	Removal
Chlorophenoxyacids	0.0%	Removal

Estimation of Raw Mixed Waste BOD:

In order to estimate the approximate BOD_5 of the combined raw waste from the Air Base and the City during the period when the industrial waste was practically nil, another series of grab samples was taken from the terminal manholes. The data developed from these samples is given in Tables VII and VIII.

The average BOD_5 of the sewage from the Air Base and the City during this period was found to be 99.4 mg/l and 104.4 mg/l, respectively. At an average total flow of 2.45 MGD, of which 1.23 MGD represented flow from the Air Base, the calculated BOD_5 for the mixed raw waste would be 102 mg/l which agrees well with the value assumed in the previous section.

TABLE VII

TERMINAL MANHOLE - AIR BASE SEWER LINE

West Jacksonville Sewage Treatment Plant

11/12 - 12/24, 1969

DATE	mg/l	pH	mg/l	Temperature °C	Total Alkalinity pH 4.2 mg/l	Chloride mg/l
11/12/69	143	7.4	0	21	270	34
11/13/69	123	7.5	0	20	277	32
11/14/69	100	7.5	0.3	20	253	35
11/17/69	134	7.2	0	20	209	24
11/19/69	74	7.0	1.0	18	119	22
11/20/69	86	7.3	3.4	17	182	17
11/21/69	60	7.1	3.0	18	138	18
11/24/69	80	7.6	0.5	19	-	-
11/28/69	27	7.3	5.5	18	-	-
12/1/69	150	7.5	0	19	-	-
12/4/69	112	7.6	0	18	292	37
12/5/69	150	7.6	0	18	285	37
12/8/69	90	7.4	2.7	16	-	-
12/10/69	98	7.5	0.9	17	-	-
12/11/69	98	7.6	2.3	13	-	-
12/12/69	130	7.6	2.0	17	-	-
12/15/69	103	7.7	0.2	17	-	-
12/17/69	108	7.5	0.9	16	-	-
12/19/69	115	7.8	0.3	16	-	-
12/22/69	53	7.4	4.3	15	-	-
12/24/69	53	7.5	4.8	15	-	-
Average:	99.4	7.47	1.15	17.5	225	28.4

(Average flow to STP - 1.23 MGD;
Total combined flow average - 2.45 MGD.)

TABLE VIII

TERMINAL MANHOLE - CITY SEWER LINE

West Jacksonville Sewage Treatment Plant

11/12 - 12/24, 1969

DATE	BOD$_5$ mg/l	pH	DO mg/l	Temperature °C	Total Alkalinity pH 4.2 mg/l	Chloride mg/l
11/12/69	137	7.5	0	21	262	39
11/13/69	100	7.5	0.3	20	233	33
11/14/69	140	7.4	0.3	18	229	34
11/17/69	148	7.1	1.4	18	143	39
11/19/69	50	6.9	1.8	18	120	22
11/20/69	100	7.2	4.1	18	138	32
11/21/69	65	7.0	2.5	18	135	27
11/24/69	77	7.4	0.7	18	-	-
11/28/69	83	7.3	3.0	17	-	-
12/1/69	157	7.5	0	18	-	-
12/4/69	138	7.4	0.2	17	211	32
12/5/69	136	7.4	0.3	15	213	39
12/8/69	49	7.2	4.8	13	-	-
12/10/69	72	7.3	1.8	16	-	-
12/11/69	113	7.4	2.7	11	-	-
12/12/69	143	7.4	2.0	16	-	-
12/15/69	150	7.2	0.4	16	-	-
12/17/69	60	7.4	2.8	16	-	-
12/19/69	115	7.6	2.3	16	-	-
12/22/69	67	7.3	4.2	14	-	-
12/24/69	93	7.3	2.9	13	-	-
Average:	104.4	7.32	2.0	16.3	187	33

(Average flow to STP - 1.23 MGD;
Total flow combined average - 2.45 MGD.)

Uniformity of Mixing:

In order to test the uniformity of mixing produced by the aerators, sixteen samples were taken approximately one foot below the surface of the lagoon. The sample points were spaced evenly from each of the aerators along the south positioning cables, four points per cable. The average DO of the samples taken was found to be 5.3 mg/l, with a range of 5.0 to 5.7 mg/l. This set of samples indicated excellent distribution of oxygen throughout the lagoon.

Visual observation of continuous movement of the floc suspended in the lagoon contents, together with consideration of the general similarity of the averaged values for suspended solids of the influent and effluent confirmed that mixing was attained in all parts of the lagoon.

Although the incoming sewage always has a low DO content, the DO content of samples taken in the immediate vicinity of aerator number 4, located above the end of the influent pipe, were nearly the same as those taken elsewhere in the lagoon.

The DO content of samples taken from the stabilization ponds, at a depth of about six inches and about two feet from the effluent weirs, was found to average 11.3 mg/l for the period May 27 through July 15, 1969, presumably due to supersaturation associated with algae photosynthesis during daylight hours. It was noted that the DO content of the samples was nearly identical in both ponds. However, quick breaking foam (similar to that of carbonated water) was observed below the spillways. This was associated with rapid loss of DO, for samples taken below each spillway at a distance of about four feet from the point of free fall invariably were found to be lower in DO than those samples taken above the spillway. The foaming was apparently the result of release of oxygen from a supersaturated condition of the water above the spillways.

It was decided to reduce the number of samples to be handled and at the same time determine the DO of the combined oxidation pond effluent, after effective mingling of the outfall of both ponds. Accordingly, a new sampling point was chosen at a point in the outfall ditch approximately in line with the south side of the south oxidation pond.

Samples taken from this point showed an average DO of 3.9 mg/l for the period July 16 through September 16, 1969. This value of DO then represented the probable average oxygen content supplied to Bayou Meto from the ponds. Surprisingly the average DO found in Bayou Meto at a point about two miles down-stream was 3.9 mg/l for the period July 16 through September 16, 1969.

SECTION VII

CHEMICAL STUDY

Sampling:

Semi-continuous Sampling:

Samples were taken regularly of the influent to and effluent from the aeration lagoon. The influent sampling point was located adjacent to the influent level recording device. The effluent sampling point was located about four (4) feet from the effluent weir.

Both sampling devices (Trebler samplers) were identical and are available commercially. They consist of narrow, clear plastic dippers mounted to rotate in a plane vertical to the water surface. The curved portion of the dipper is designed to remove a portion of water proportional to the flow at the time of dipping. A 1/150th HP motor drives the dipper by means of a chain geared to produce one revolution in about two minutes. At the average flow rate (@ 2.2 MGD) the samplers were set to take a sample every 12 minutes. This was accomplished by means of an adjustable interval timer and micro-switch cut-off. Total sample volume varies somewhat with the daily flow but averages about 2.25 gallons.

The samples taken at both points were fed into plastic pipe and containers. The containers were square, flexible polyethylene bottles enclosed in a close-fitting wooden box for ease in handling. They were housed within small square electric refrigerators which are obtainable locally. The shelving and other internal pans were removed to provide room for the containers. Inlet openings were bored carefully through the insulating wall for the sample tubing and for a small vent opening. These were sealed after placing supporting pipe and small glass tube for the vent, to prevent moisture collecting within the walls. The small refrigerators were protected from direct sunlight and rain by small plywood sheds painted white to reflect as much as practicable. In this way the samples taken semi-continuously could be chilled almost immediately to a temperature of 5-10°C (40-50°F).

Spot Sampling:

"Grab" samples were taken regularly of the influent and

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effluent for the measurement of temperature and for DO determinations. Grab samples of stabilization pond effluent were taken because the detention time of the ponds was about 25-30 days, hence changes were not rapid. Grab samples were necessary at several other points because suitable continuous sampling equipment was not available. One battery operated type was tried with poor performance because of solids accumulation in the pumping mechanism.

Methods of Analysis:

The methods of analysis used for the determination of the values reported here were those set forth in the book "Standard Methods for the Examination of Water and Waste Water," 12th Edition (1965), with the exception of the determination of chlorophenols and chlorophenoxyalkanoic acids.

Chlorophenols present in the waste samples were determinable by three methods:

1. The first method was that set forth in "Standard Methods" for phenol which involves distillation of a portion of the sample at pH 4.0 to separate the phenolic fraction, followed by treatment to develop a colored solution. The color intensity developed in the treated solution is compared with that developed in standard solutions of known strength by means of a Bausch and Lomb colorimeter. The method was originally devised for phenol and relatively simple derivatives, for which it is quite satisfactory. However, the colors developed are not all alike nor does color development occur at the same rate for various phenolic materials. Where mixtures are involved, application of the standard method is not a method of choice. In the present case, the method gave lower results because of the mixtures encountered and because of the difficulty of co-distillation of the family of chlorinated phenol compounds present. The number of grams of water per gram of compound to be volatilized increases enormously at low concentration, since the rate of co-distillation is proportional to the mole fraction of the compound to be distilled and to its vapor pressure at the temperature of the distillation.

2. The second method, which was adopted as the routine method, involved pH adjustment of a 50 ml measured sample by the addition of solid sodium bicarbonate. Approximately 0.5 gm of sodium bicarbonate was sufficient for samples with an initial pH of 6 to 8; samples outside this range were first adjusted by the dropwise addition of

dilute hydrochloric acid or sodium hydroxide. After pH adjustment, the chlorophenols were extracted into an equal volume of spectro-grade isooctane containing 5% by volume of tributylphosphate, using a glass stoppered conical separator fitted with a Teflon stopcock plug. The upper layer containing the chlorophenols was isolated by draining away the lower water layer into a second separator. The solvent layer was washed once with about 5 mls of water down the neck and sides of the original separator (not shaken - merely to wash the walls). The wash water was drained to the second separator and combined with the water raffinate layer. This layer was retained for later similar extraction of the more acidic materials present in the sample after careful acidification with 10 mls of 1:1 hydrochloric acid and elimination of carbon dioxide.

The washed solvent layer containing chlorophenols was passed through a small dry filter paper into a small Erlenmeyer flask. Portions of the filtered extract were then used to rinse and finally fill a 10 cm fused quartz cuvette. The filled cuvette was placed in the sample-side cuvette holder of a Cary-15 double-beam spectrophotometer for visible or ultraviolet work. The absorption spectrum of the sample solution was then obtained in the wavelength range 2400 to 3500 Angstroms relative to a portion of the clean extracting solvent used in the matching cuvette of the spectrophotometer.

Although the specific absorption spectra of the different compounds which were to be expected are different in magnitude at many wavelengths, they are sufficiently close to permit reasonable quantitative estimation of total phenols at the wavelength of 2,915 Angstroms.

3. The third method involved carbon tetrachloride extraction of a measured portion of the sample, after pH adjustment with solid sodium bicarbonate. The extraction was done in 1000 ml Erlenmeyer flasks. The flasks were fitted with a ground glass stopper at the top and with a short, approximately 8 mm glass tube and stopcock fused to the side of the flask at a point as close as possible to the flat bottom. (This point allows the flask to sit on a magnetic stirrer without tilt, but also permits draining away the heavier than water extract layer.) Extraction is accomplished by adding a measured amount of sample together with a measured amount of extracting solvent to the extractor containing a Teflon coated or glass enclosed magnet. The clean ungreased stopper is placed and the contents is stirred on a magnetic stirrer for five minutes. Stirring is carried out so that a vortex develops,

sufficing to bring the heavy extracting liquid into intimate contact with the water layer. Violent stirring sometimes caused emulsification which may be broken on standing or by the addition of a small quantity of chloroform.

The separate extract is filtered to remove traces of liquid water and evaporated to dryness in a water aspirator vacuum at 35-40°C. The residue is dissolved in 1 ml of carbon tetrachloride containing a known concentration of pure ethyl palmitate as an internal standard. This solution is then examined by gas-liquid chromatography using hydrogen flame detection. Typical conditions are given below:

Column:	5 feet of 1/8 inch pyrex glass tubing.	
Packing:	1.5% FFAP (Varian Aerograph Co.) on Chromosorb G acid washed DMCS - 100/120 mesh.	
Conditions:	Injector Temp.	200°C
	Column Temp.	150°C
	H_2 flow	25 ml/min
	N_2 flow	25 ml/min
	Air flow	125 ml/min
	Chart Speed	0.5 in/min

The chromatograph obtained reveals the individual chlorophenols present together with the standard substance in the extract.

The order of elution is:

1. ortho-chlorophenol
2. phenol
3. 2,6-dichlorophenol
4. 2,5-dichlorophenol
5. 2,4-dichlorophenol
6. ethyl palmitate
7. 2,4,6-trichlorophenol
8. para-chlorophenol
9. 2,4,5-trichlorophenol

By comparison of the retention volumes for various pure chlorophenols, the presence of various components in the sample may be determined. Quantitative amounts present may be estimated by comparison of the relative areas under the corresponding peaks of the chromatograph with that of the internal standard.

This method may be reasonably extended to low concentrations by multiple extraction prior to concentration in vacuum. As applied here, 500 to 1000 ml of sample were extracted with a minimum of three (3) successive 50 ml portions of carbon tetrachloride, effecting a 500:1 to 1000:1 concentration of the chlorophenolics present.

Routine Sampling and Analyses:

Routine sampling and analyses were begun as soon as the automatic samplers were installed and adjusted to provide an adequate volume of sample per day. A summary of the data obtained from samples of aeration lagoon influent and effluent, stabilization ponds and Bayou Meto at Arkansas Highway 161 during the period May 27 through September 30, 1969 is presented in Table IX.

Total and suspended solids of the samples of stabilization pond effluent and Bayou Meto are not shown since the greatest attention was placed upon the determinations reported.

The figures given in brackets under Industrial Effluent are not representative averages, but are intended to give an order of magnitude. They are the averages of several determinations made during the preliminary study. The industrial plant was forced by other circumstances to curtail the manufacture of chlorophenoxy acids shortly after the time routine analyses were begun. A more complete study was done later in early 1970 after the plant began temporary continuous operation.

The loading and average unit efficiencies of the aeration lagoon and the stabilization ponds during this period are given in Tables X and XI. Percent total reduction across lagoon and stabilization pond appears in brackets in the table.

Sampling and analysis were continued during the three (3) month period that the No. 1 aerator was out of service for repair of the gear speed reducing mechanism. The data obtained at that time, broken into two intervals, is summarized in Table XII. The figures given in the table represent average values obtained for the number of samples noted in each column.

Using the data shown in Table XII, the averaged load on the West STP contributed by the industrial waste may be estimated. This loading and the subsequent disposition of BOD_5, phenols and phenoxy-acids across the aerated

TABLE IX

DATA OBTAINED 5/27 - 9/30, 1969

	Industrial Effluent	Aeration Lagoon Influent	Aeration Lagoon Effluent	Stabilization Pond Effluent	Bayou Meto at Hwy 161
Temp. °C	(17.5)	25.5	26.8	27.3	25.2
pH	(7.3)	6.9	6.8	8.3	6.8
Total Alkalinity pH 4.2 mg/l	(1720)	163	108	119	66
Settleable Solids ml/l	(25)	3.6	5.3	Tr.	Tr.
Total Solids mg/l	(53120)	580	532	--	--
Suspended Solids mg/l	(1255)	110	108	--	--
Chloride mg/l	(26950)	206	174	183	54
DO mg/l	--	0.7	5.5	11.3 3.9	3.9
BOD_5 mg/l	(4340)	72	26	10.4	(3)
COD mg/l	--	210	100	55	27.5
Phenols mg/l	141	0.8	0.2	0.06 0.07*	0.05 0.08*
Phenoxy Acids mg/l	370			1.06*	0.85*
Volume/Day	13340 gpd	2.22 mgd	(2.22) mgd	1.91 mgd	--
Number of Samples	12	88	78	85 21*	55 39*

*Data from UV Method.

TABLE X

LOADING AND DISPOSITION
5/27 - 9/30, 1969

		Aeration Lagoon Influent	Aeration Lagoon Effluent	Stabilization Pond Effluent
Total Alkalinity pH 4.2	Lbs./Day	3015	1997	1893
Chloride	Lbs./Day	3809	3218	2911
BOD_5	Lbs./Day	1331	481	165
COD	Lbs./Day	3883	1849	875
Phenols	Lbs./Day	14.8	3.7	1.1

TABLE XI

AVERAGE UNIT EFFICIENCIES
WEST JACKSONVILLE SEWAGE TREATMENT PLANT
5/27 - 9/30, 1969

		Aeration Lagoon		Stabilization Pond	
Raw Flow (MGD)		2.22		1.91	
		ppm	Lbs./Day	ppm	Lbs./Day
Total	Influent	163	3015	108	1997
Alkalinity	Effluent	108	1997	119	1893
to pH 4.2	% Reduction		33.8		5.2
mg/1					(37)
Settleable	Influent	3.6		5.3	
Solids	Effluent	5.3		Tr.	
ml/1	% Reduction	0.0		100	(100)
BOD_5	Influent	72	1311	26	481
mg/1	Effluent	26	481	10.4	165
	% Reduction		63.3		65.7
					(87)
COD	Influent	210	3883	100	1849
mg/1	Effluent	100	1849	55	875
	% Reduction		52.3		52.7
					(77)
Phenols	Influent	0.8	14.8	0.2	3.7
mg/1	Effluent	0.2	3.7	0.07	1.1
	% Reduction		75.0		70.3
					(92)

TABLE XII

DATA OBTAINED WHILE AERATOR NUMBER 1 WAS NOT OPERATING 1/17 - 4/17, 1970

	Industrial Effluent		Aeration Lagoon Influent		Aeration Lagoon Effluent		Stabilization Pond Effluent	
	1/17-3/7	3/10-4/17	1/17-3/7	3/10-4/17	1/17-3/7	3/10-4/17	1/17-3/7	3/10-4/17
Temp. °C	7.1	15.1	12.5	14.8	10.2	13.7	8.0	13.7
pH	7.35	7.33	6.9	7.15	7.2	7.2	7.55	8.1
Total Alkalinity to pH 4.2 mg/1	763	2176	107	145	106	132	102	109
Settleable Solids ml/1	7.7	24.4	2.5	3.2	0.25	0.51	Tr.	Tr.
Chloride mg/1	5848	21688	91.5	309	86	268	90	226
DO mg/1	(4-6)		(0-3.5)		(4.5-6.5)		5.9	10.9
BOD$_5$ mg/1	704	2456	70.3	88.5	22.7	23.2	13.4	15.9
Phenols mg/1	84.7	153.7	1.02	1.65	0.45	0.21	0.13	0.10
Phenoxy Acids mg/1	154.4	296.6	2.15	4.14	1.51	1.73	1.10	1.48
Number of Samples	23	15	18	17	23	15	19	20
Volume/Day	41960 gpd	47500 gpd	3.21 mgd	3.47 mgd	3.21 mgd	3.47 mgd	3.13 mgd	3.34 mgd

lagoon and stabilization ponds is shown in Table XIII.

The unit efficiencies are shown in Table XIV.

After the Number 1 aerator had been replaced in service, the continuing study yielded data summarized in Tables XV and XVI. The loading and unit efficiencies for the periods 4/20-5/11, 1970 and 5/11-6/12, 1970 are shown in Tables XVII and XVIII and Tables XIX and XX, respectively.

The results of analyses of the industrial plant waste effluent at intervals are shown in Table XXI to illustrate the variability of this stream over the period of start-up, operation and after shut-down of the chemical plant.

Table XXI-A presents the relative content of various chlorophenols present in the samples reported in Table XXI.

Figure 1 shows the variation in chloride content of the stabilization pond effluent with time in relation to the number of pounds per day of chloride discharged from the industrial plant.

Studies of Varied Operation:

Although the main object of the project work was the joint treatment of industrial-domestic waste, it seemed desirable to study the treatment of the domestic waste with a low level of industrial waste through the aeration lagoon only. For this reason the conventional treatment section of the process was valved out of service on July 10, 1970. Accordingly, continued sampling of the aeration lagoon influent was typical of the combined raw waste from the city and the air base. For a period all four aerators were continued in operation. Then for six successive weeks, aerators were turned off while the rest ran in the following pattern:

	Aerators Running	Aerators Off
First Week:	2, 3 and 4	1
Second Week:	1, 3 and 4	2
Third Week:	1, 2 and 4	3
Fourth Week:	1 and 4	2 and 3
Fifth Week:	2 and 4	1 and 3
Sixth Week:	3 and 4	1 and 2

Routine sampling was continued through this period and the averaged results of analysis are shown in Table XXII. The data shown is limited to chloride, BOD_5 and volume

TABLE XIII

AVERAGED LOADING OF INDUSTRIAL WASTE AND ITS DISPOSITION 1/17 - 4/17, 1970

	Industrial Waste		Aeration Lagoon Influent		Aeration Lagoon Effluent		Stabilization Pond Effluent	
	1/17-3/7	3/10-4/17	1/17-3/7	3/10-4/17	1/17-3/10	3/10-4/17	1/17-3/7	3/10-4/17
Settleable Solids (CFD)	43	155	1075	1490	108	237	--	--
Chloride ion (Lbs./Day)	2044	8580	2447	8930	2300	7746	2347	6288
BOD_5 (Lbs./Day)	246	972	1880	2558	607	671	349	442
Phenols (Lbs./Day)	30	61	27	48	12	6	3.4	2.8
Phenoxy Acids (Lbs./Day)	54	117	57	120	40	50	29	41
Volume/Day	41960	47500	3.21	3.47	3.21	3.47	3.13	3.34

TABLE XIV

UNIT EFFICIENCIES

		Aeration Lagoon	Stabilization Ponds	Overall
1/17-3/7, 1970				
BOD$_5$ Lbs./Day	Influent	1880	607	
	Effluent	607	349	
	% Reduction	67.7	42.5	81.4
Phenols Lbs./Day	Influent	27	12	
	Effluent	12	3.4	
	% Reduction	55.5	71.6	87.4
Phenoxy Acids Lbs./Day	Influent	57	40	
	Effluent	40	29	
	% Reduction	29.8	27.5	49.1
3/10-4/17, 1970				
BOD$_5$ Lbs./Day	Influent	2558	671	
	Effluent	671	442	
	% Reduction	73.7	34.1	82.7
Phenols Lbs./Day	Influent	48	6	
	Effluent	6	2.8	
	% Reduction	87.5	53.3	94.1
Phenoxy Acids Lbs./Day	Influent	120	50	
	Effluent	50	41	
	% Reduction	58.3	18	65.8

TABLE XV

DATA OBTAINED 4/20 - 5/11, 1970

		Industrial Effluent	Aeration Lagoon Influent	Aeration Lagoon Effluent	Stabilization Pond Effluent
Temperature °C		24	18.8	19.4	22.5
pH		7.4	7.2	7.3	7.65
Total Alkalinity pH 4.2	mg/1	2806	156	134	138
Settleable Solids	ml/1	32	3.7	2.9	0.2
Chloride	mg/1	28305	377	352	316
DO	mg/1	3.5	2.4	6.6	5.4
BOD_5	mg/1	2896	80	25.6	14.3
Phenols	mg/1	103.8	1.22	0.13	0.1
Phenoxy-Acids	mg/1	198	2.58	1.12	1.12
Number of Samples		14	13	13	14
Volume/Day		46890 gpd	3.47 mgd	3.47 mgd	3.44 mgd

TABLE XVI

DATA OBTAINED 5/11 - 6/12, 1970

		Industrial Effluent	Aeration Lagoon Influent	Aeration Lagoon Effluent	Stabilization Pond Effluent
Temperature °C		26.7	23.3	24	26.8
pH		7.2	7.3	7.0	8.95
Total Alkalinity pH 4.2	mg/1	1829	163	141	128
Settleable Solids	ml/1	29	3.7	2.6	0.31
Chloride	mg/1	27055	343	404	442
DO	mg/1	3.2	2.3*	7.3	6.0
BOD_5	mg/1	2673	114	31.4	15
Phenols	mg/1	77	1.2	0.2	0.08
Phenoxy-Acids	mg/1	275	3.64	1.0	0.77
Number of Samples		44	38	37	39
Volume/Day		29590 gpd	2.35 mgd	2.35 mgd	2.14 mgd

*Grab samples were nearly always 0 to 0.1 DO.

TABLE XVII

AVERAGED LOADING OF INDUSTRIAL WASTE AND ITS DISPOSITION
4/20 - 5/11, 1970

		Industrial Effluent	Aeration Lagoon Influent	Aeration Lagoon Effluent	Stabilization Pond Effluent
Total Alkalinity pH 4.2	Lbs./Day	1096	4509	3873	3954
Settleable Solids	CFD	201	1720	1348	92
Chloride	Lbs./Day	11056	10897	10175	9055
BOD_5	Lbs./Day	1131	2312	740	410
Phenols	Lbs./Day	40.5	35.3	3.8	2.9
Phenoxy Acids	Lbs./Day	77.3	74.6	32.4	32.1

TABLE XVIII

AVERAGED LOADING OF INDUSTRIAL WASTE AND ITS DISPOSITION
5/11 - 6/12, 1970

		Industrial Effluent	Aeration Lagoon Influent	Aeration Lagoon Effluent	Stabilization Pond Effluent
Total Alkalinity pH 4.2	Lbs./Day	451	3191	2760	2282
Settleable Solids	CFD	115			
Chloride	Lbs./Day	6669	6714	7909	7880
BOD_5	Lbs./Day	659	2232	615	267
Phenols	Lbs./Day	19	23.5	3.9	1.4
Phenoxy Acids	Lbs./Day	68	71	19.6	13.7

TABLE XIX

UNIT EFFICIENCIES

4/20 - 5/11, 1970

		Aeration Lagoon	Stabilization Ponds	Overall
BOD_5	Influent	2312	740	
	Effluent	740	410	
	% Reduction	68	46	82.3
Phenols Lbs./Day	Influent	35.3	3.8	
	Effluent	3.8	2.9	
	% Reduction	89.2	23.7	91.8
Phenoxy Acids Lbs./Day	Influent	74.6	32.4	
	Effluent	32.4	32.1	
	% Reduction	56.5	0.9	57

TABLE XX

UNIT EFFICIENCIES

5/11 - 6/12, 1970

		Aeration Lagoon	Stabilization Ponds	Overall
BOD_5 Lbs./Day	Influent	2232	615	
	Effluent	615	267	
	% Reduction	72.4	56.6	88.0
Phenols Lbs./Day	Influent	23.5	3.9	
	Effluent	3.9	1.4	
	% Reduction	83.4	64.1	94.0
Phenoxy Acids Lbs./Day	Influent	71	19.6	
	Effluent	19.6	13.7	
	% Reduction	72.39	30.1	80.7

TABLE XXI

ANALYSIS OF INDUSTRIAL PLANT WASTE
1970

Date Sampled		January 25	March 3	April 21	May 28	August 27
Temperature - °C		12	18	21	28.5	24
pH		7.5	7.6	7.4	7.4	7.0
Total Alkalinity to pH 4.2	mg/1	560	2250	3960	4510	305
BOD_5	mg/1	515	1680	3840	6315	400
COD	mg/1	700	2500	6200	8315	1290
Total Solids	mg/1	6960	40100	76320	104860	11000
Suspended Solids	mg/1	160	360	380	580	nil
Settleable Solids	mg/1	6	16	40	40	1.3
Chloride	mg/1	3000	19350	37350	52150	4950
Chlorophenols	mg/1	68	118	125	112	74
Phenoxy-acids	mg/1	167	183	241	235	199
Volume	Gallons	9950	95430	30320	20650	1450
DO	mg/1	6	5.8	3.0	-	-
Weather		Clear	Heavy Rain	Clear	Clear	Clear

TABLE XXI-A

RELATIVE CHLOROPHENOL CONTENT OF INDUSTRIAL WASTE
1970

Date Sampled	January 25	March 3	April 21	May 28	August 27
	%*	%*	%*	% *	%*
Phenol Type					
2-chloro-	2.9	6.1	Tr	Tr	Tr
Phenol	3.4	6.2	1.7	24.8	Tr
2,6-dichloro-	9.9	41.7	38.8	30.5	3.0
2,5-dichloro-	Tr	6.2	1.7	Tr	1.8
2,4-dichloro-	73.6	17.9	20.0	11.4	89.0
2,4,6-trichloro-	2.8	9.9	19.5	13.3	3.4
4-chloro-	2.5	12.1	18.3	20.0	2.8
2,4,5-trichloro-	4.7	Tr	Tr	Tr	Tr

*Percent of total phenols present.

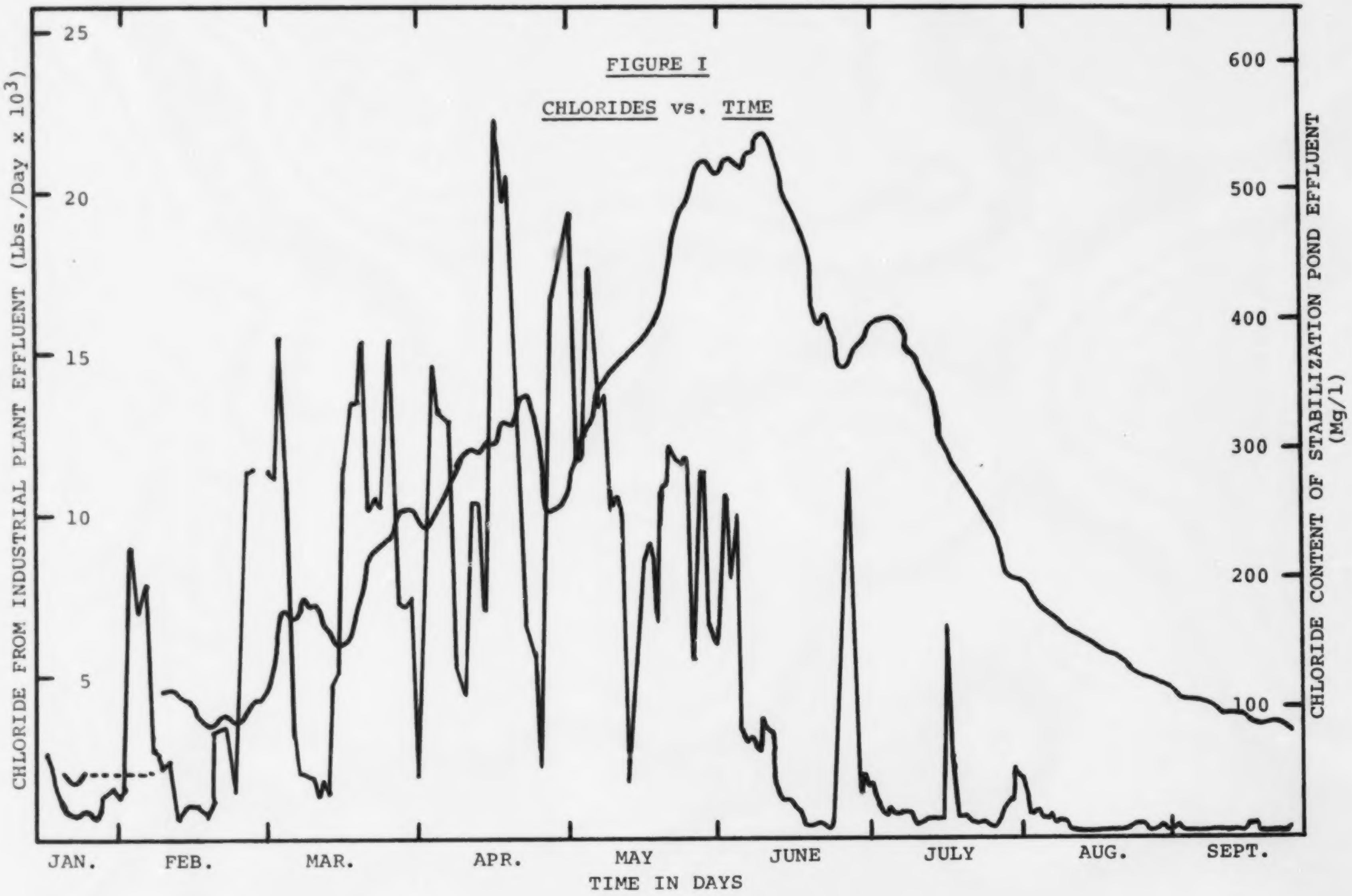


FIGURE I

CHLORIDES vs. TIME

TABLE XXII

AVERAGED DATA OBTAINED 7/13 - 9/11, 1970
DURING OPERATION AS INDICATED
(Conventional System Bypassed)

		PLANT EFFLUENT			AERATION INFLUENT			AERATION EFFLUENT			STABILIZATION POND EFFLUENT		
DATE	AERATION	Cl$^-$ lb/day	BOD5 lb/day	V gal/day	Cl$^-$ lb/day	BOD5 lb/day	V MGD	Cl$^-$ lb/day	BOD5 lb/day	V MGD	Cl$^-$ mg/1	BOD$_5$ mg/1	DO mg/1
7/13 to 7/31	4 (1,2,3,4)	540	56	7400	1499	1907	2.12	1621	699	(2.12)	267	10.1	6.4
8/1 to 8/6	3 (2,3,4)	240	23	4650	916	1858	2.03	1212	541	(2.03)	185	12.2	5.6
8/7 to 8/14	3 (1,3,4)	105	12	2610	1005	1930	2.09	1147	582	(2.09)	162	10.3	5.8
8/15 to 8/20	3 (1,2,4)	59	6	1440	834	1915	1.94	944	583	(1.94)	143	11.5	5.7
8/21 to 8/28	2 (1,4)	99	8	2350	849	1917	2.09	948	462	(2.09)	128	13.0	6.1
8/29 to 9/4	2 (2,4)	90	7	1915	1096	2015	2.25	980	535	(2.25)	112	13.3	5.9
9/5 to 9/11	2 (3,4)	75	5	1505	850	1620	2.04	956	217	(2.04)	100	9.5	5.9

for the industrial plant effluent, lagoon influent and effluent and pond effluent.

Table XXIII presents the apparent efficiency of the aeration lagoon alone during this time of staggered operation. Although this data is limited, it appears to show an upward trend in efficiency with decrease in the number of aerators functioning.

East Jacksonville STP Analyses:

A series of 15 grab samples was taken from points in the East Jacksonville Sewage Treatment Plant between 9/16 and 11/10, 1969 as a check on the BOD_5 of that system for purposes of comparison. The averaged values found are presented in Table XXIV.

Receiving Stream Analyses:

A summary of data obtained on samples taken from Bayou Meto at Arkansas Highway 161 at a point roughly two (2) miles from the receiving point of the stream is given in Table XXV.

BOD-COD Relationship:

A series of BOD_5 and COD values for unfiltered samples taken during the period July 17 to August 7, 1969 are shown in Table XXVI. These were obtained during full operation of the joint treatment process, but at a time of reduced industrial waste flow. The average reduction in BOD_5 across the lagoon from this data is 60.8%, while that of the COD is 53%, with a detention time of about 3.5 days.

BOD of the Industrial Plant Waste:

Glycolic acid and, to a lesser extent, acetic acid are present in the industrial plant waste at variable levels of concentration. The glycolic acid arises from hydrolysis of a portion of the mono-chloroacetic acid used in the plant processes. The acetic acid is present as a contaminant of hydrochloric acid generated during manufacture of mono-chloroacetic acid and, to a lesser extent, as a contaminant of the mono-chloroacetic acid produced. Each of these compounds is susceptible to bacterial oxidation, and they constitute the major portion of the organic loading of the industrial plant waste.

TABLE XXIII

APPARENT EFFICIENCY OF AERATION LAGOON WITH LOW INDUSTRIAL WASTE - CONVENTIONAL SYSTEM BYPASSED AND ALL OR FEWER AERATORS OPERATING.

DATE	AERATORS OPERATING	BOD_5 In lbs./day	BOD_5 Out lbs./day	BOD_5 Removed lbs./day	% BOD_5 Removed	Average Settleable Solids in Effluent mls/l
1970 7/13-7/31	4 (all)	1907	699	1208	63	1.9
8/1-8/6	3 (2,3,4)	1858	541	1317	71	.45
8/7-8/14	3 (1,3,4)	1930	582	1348	70	.77
8/15-8/20	3 (1,2,4)	1915	583	1332	70	.90
8/21-8/28	2 (1,4)	1917	462	1445	75	1.06
8/29-9/4	2 (2,4)	2015	535	1480	73	.64
9/5-9/11	2 (3,4)	1620	217	1403	86	.10

TABLE XXIV

DATA FROM EAST JACKSONVILLE SEWAGE TREATMENT PLANT

9/16 - 11/10, 1969

	S.T.P. Influent	Stabilization Pond Influent	Stabilization Pond Effluent
Temperature - °C	20.8	16.7	12.5
pH	7.3	7.0	7.7
Total Alkalinity mg/l	281	132	210
Chloride mg/l	36	23	33
Initial DO mg/l	0	2.5	4.7
BOD_5 mg/l	115	51	19.5
Phenols (Total) mg/l	0.2	-	0.04
% Reduction:			
Phenols - 81.0			
BOD_5 - 83.0			

TABLE XXV

BAYOU METO AT ARKANSAS HIGHWAY 161
(Roughly 2 miles from Receiving Point)

	Temp. (°C)	pH	DO (mg/1)	BOD_5 (mg/1)	Total Alkalinity (mg/1)	Chloride (mg/1)	Phenols (mg/1)	Phenoxy Acids (mg/1)
1969:								
April	17.6	6.7	7.0		33	28	0.03	
May	17.9	6.6	5.2		54	53	0.03	
June	23.1	6.7	3.7		68	64	0.03	
July	27.6	6.8	2.5		85	86	0.07	
Aug.	25.4	6.9	3.2		87	46	0.07	
Sept.	23.2	7.2	3.9		116	62	0.05	
Oct.							0.07	0.6
Nov.							0.05	0.5
Dec.							0.04	0.35
1970:								
Jan.	4.3	7.3	9.9	4	57	13	0.04	0.37
Feb.	5.8	6.5	9.7	3.8	21	8.3	0.05	0.5
Mar.	11.1	6.7	8.9	3.0	33	7.8	0.045	0.45
Apr.	16.6	6.8	7.3	3.0	42	19	0.04	0.42
May	22.0	6.9	5.4	4.5	61	121	0.055	0.46
June	24.5	7.5	5.9	7.6	109	278	0.05	0.55
July	26.1	8.3	6.3	9.6	90	272	0.065	0.50
Aug.	25.9	7.3	4.9	6.4	79	130	0.06	0.59
Sept.	26.5	7.45	5.35	6.6	83	105	0.05	0.46

TABLE XXVI

BOD - COD RELATIONSHIP - AERATED LAGOON 7/17 - 8/7, 1969

1969	Aeration Lagoon Influent BOD5 mg/1	Aeration Lagoon Influent COD mg/1	Weather and Rain In Inches	Aeration Lagoon Effluent BOD5 mg/1	Aeration Lagoon Effluent COD mg/1	Influent Volume mgd	Stabilization Ponds Effluent BOD5 mg/1	Stabilization Ponds Effluent Vol. mgd
7/17	88	305	c	29	117	2.16	4.5	1.46
7/18	53	280	c	25	116	2.21	2.5	1.40
7/19	76	199	c	36	79	2.17	8.2	1.38
7/20	67	228	c	21	91	2.17	8.6	1.46
7/21	41	176	c	15	97	2.34	15.6	1.38
7/22	71	355	c	15	78	2.17	12.5	1.40
7/23	67	215	c	28	150	2.21	17.0	1.46
7/24	76	160	1.06	20	53	2.17	16.0	2.40
7/25	75	291	.04	37	210	2.87	9.0	3.50
7/26	66	142	c	35	64	2.71	9.3	2.60
7/27	82	177	1.20	31	124	2.34	13.2	2.34
7/28	70	234	c	26	127	3.25	13.2	3.02
7/29	76	216	c	25	117	3.02	15.2	2.54
7/30	64	168	c	36	168	2.70	14.8	2.26
7/31	70	152	c	26	46	2.48	10.9	1.86
8/1	58	135	c	31	52	2.33	10.2	1.76
8/2	55	199	c	24	89	2.23	16.0	1.60
8/3	52	113	c	20	31	2.44	13.0	1.42
8/4	66	152	c	18	78	2.00	8.3	1.34
8/5	68	269	c	25	106	2.45	8.6	1.40
8/6	50	191	c	24	85	2.15	4.5	1.38
8/7	58	289	c	21	104	1.98	2.5	1.52
Averages:	65.9	211.2		25.8	99.2	2.39	10.6	1.86

Average detention time in 8.4 MG Lagoon 3.5 days

Average Lbs/Day:	Aeration Lagoon Influent BOD5	Aeration Lagoon Influent COD	Aeration Lagoon Effluent BOD5	Aeration Lagoon Effluent COD
	1312	4205	514	1975

Average Reduction Across Lagoon: BOD_5 - 60.8% COD - 53.0%

Standard BOD tests were applied to show that the acclimated bacterial population in the aeration lagoon effluent can readily promote oxidation of both glacial acetic acid and reagent grade mono-chloroacetic acid as well as hydrolyzed mono-chloroacetic acid when these substances are added as the neutral salts. The following results were obtained:

	Concentration mg/l	BOD_5 Found mg O_2/mg	BOD Theoretical mg O_2/mg	% of Theoretical
Acetic Acid	4.07	0.762	1.066	71.5
Mono-chloroacetic Acid	8.47	0.390	0.508	76.8
Glycolic Acid	6.82	0.484	0.631	76.7

The COD values determined for the prepared solutions ranged from 97.5 to 99 percent of the theoretical values. The interference possible from the presence of chloride was eliminated by the use of mercuric sulfate as directed in Standard Methods. Care was taken to add the silver-sulfuric acid down the condensers to avoid loss of acetyls.

SECTION VIII

RATE STUDIES

A typical determination of the rate constant, k, in the case of a grab sample of aeration lagoon influent is presented in Table XXVII. It was noted generally that the initial rate constant appeared to be larger than the average for a particular experiment. This was interpreted as the result of variable ease of oxidation of the various components of the complex mixture in the aeration lagoon influent.

In order to demonstrate the degradation of chlorophenols and chlorophenoxy-acids in the industrial plant waste stream _in vitro_, at a much higher concentration than that encountered in the normal aeration lagoon influent, a 1:11 dilution of the plant effluent was made with aeration lagoon effluent. 1,600 ml of industrial plant effluent was mixed with 16,000 ml of aeration lagoon effluent. The results obtained on samples taken during continuous aeration of this mixture are shown in Table XXVIII. A plot of the $\log_{10}$ of the percent BOD_5 remaining versus time in days is shown in Figure 2. The estimated rate constant, k, in the equation:

$$\log_{10}\%\ BOD_5\ \text{Remaining} = 2 - kt$$

in which t represents time in days, was found to be 0.145. The overall reduction in BOD_5 was 85% in six days, while the reduction in chlorophenols and chlorophenoxy-acids, respectively, was 97% and 32% in seven days. The change in chlorophenol content is shown graphically in Figure 3.

Another experiment with the same sample of industrial plant effluent, diluted 1:100 with aeration lagoon effluent was made to demonstrate the rate of oxygen uptake. A portion of aeration lagoon effluent which had been aerated in a glass bottle for 48 hours was used to prepare the dilution. 400 ml of industrial plant waste were added to 3,600 ml of the lagoon effluent. Immediately after mixing, a 400 ml portion of the initial dilution was added to a second 3,600 ml portion of the lagoon effluent. This final mixture was mixed rapidly and filled into DO bottles which were then stored in the incubator. Each of the solutions had been maintained at 20-21°C, which was the temperature maintained in the laboratory. The results of DO determinations made immediately after mixing and at intervals of about one hour are shown in Table XXIX. A plot of $\log_{10}$ % DO remaining versus time in days is shown in Figure 4.

TABLE XXVII

DATA FOR RATE CONSTANT, k, OF OXYGEN UTILIZATION OF AERATION LAGOON INFLUENT

Date: 7/25/69 pH = 7.3 Dilution: 5%

Bottle No.	Time (Days)	DO mg/l	% DO Remaining	k
90	0	7.7	100	
92	0.75	6.5	84.4	.098
93	1.72	5.9	76.6	.067
100	2.69	5.5	71.4	.054
111	3.73	4.9	63.6	.053
112	4.70	4.3	55.8	.054
117	5.70	4.15	53.9	.047

Average = .062

Slope of $\log_{10}$ % DO_R versus time = .054

Probable BOD_5 of Aeration Lagoon Influent - 83 mg/l

TABLE XXVIII

AERATED MIXTURE OF PLANT EFFLUENT AND AERATION LAGOON EFFLUENT (11:1 RATIO)

5/27/70	pH	Total Alkalinity To pH 4.2 mg/1	Chloride mg/1	COD Millipore Filtered	BOD mg/1	Phenols mg/1	Phenoxy-Acids mg/1
"A" Plant Effluent	7.30	4442	51660		5225	115.3	2326
"B" Aeration Lagoon Effluent	7.95	194	595		41	0.09	0.78
1600 ML "A" 16000 ML "B" Mixed							
5/27/70	7.65	596	5230		500	9.5	23.9
5/28/70	7.65	594	--	520	340	8.3	23.9
5/29/70	7.95	620	--	--	305	6.1	24.0
5/31/70	7.95	674	--	127	183	--	--
6/1/70	7.95	620	--	120	133	1.1	21.5
6/2/70	7.95	388	--	--	70	0.55	20.8
6/3/70	8.00	392	5235	--	78	0.44	19.1
6/4/70	7.95	--	--	--	--	0.28	16.2
Percent Overall Reduction		34.5%			85%	97%	32%

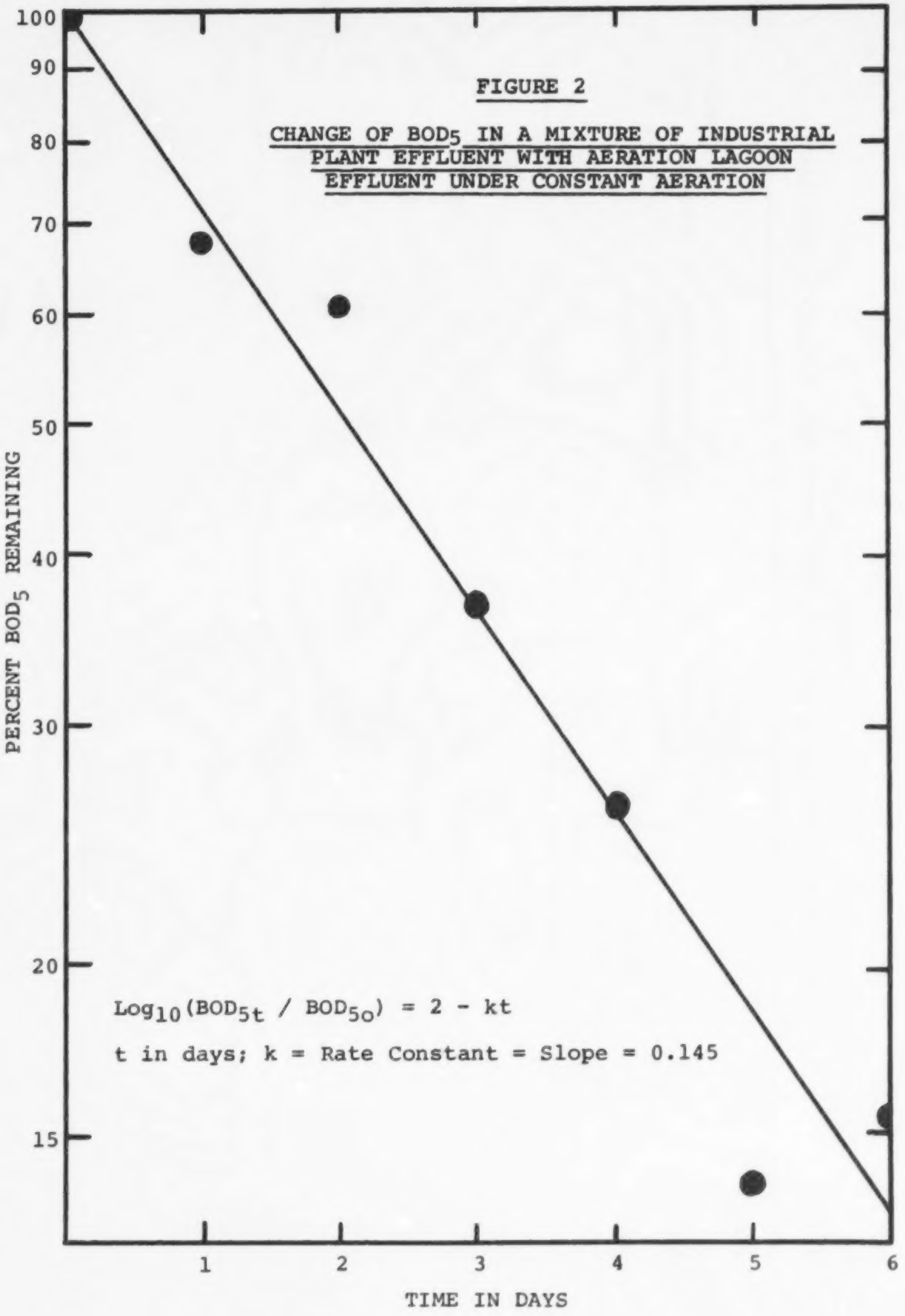


FIGURE 2

CHANGE OF BOD5 IN A MIXTURE OF INDUSTRIAL PLANT EFFLUENT WITH AERATION LAGOON EFFLUENT UNDER CONSTANT AERATION

$\mathrm{Log}_{10}(\mathrm{BOD}_{5t} / \mathrm{BOD}_{5o}) = 2 - kt$

t in days; k = Rate Constant = Slope = 0.145

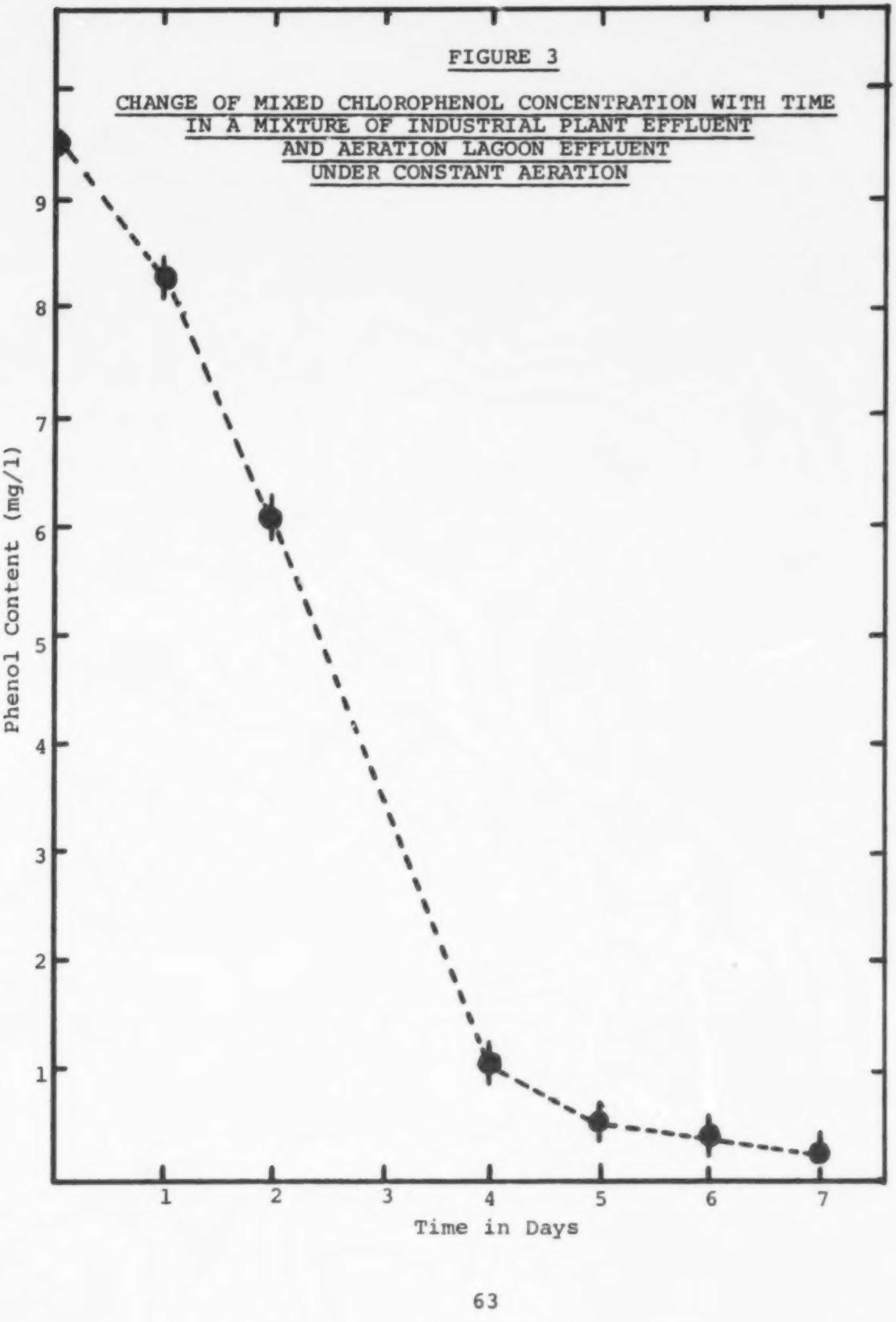


FIGURE 3

CHANGE OF MIXED CHLOROPHENOL CONCENTRATION WITH TIME IN A MIXTURE OF INDUSTRIAL PLANT EFFLUENT AND AERATION LAGOON EFFLUENT UNDER CONSTANT AERATION

TABLE XXIX

CHANGE IN DO CONTENT OF 1:100 DILUTION OF INDUSTRIAL PLANT EFFLUENT IN AERATION LAGOON EFFLUENT

Temp. = 20°C pH = 7.25

Time (min.)	Bottle No.	DO (mg/l)	% DO Remaining	Time (days)
0	76	8.1	100	0
60	81	6.8	84	0.042
136	84	5.0	62	0.094
189	87	3.9	48	0.131
280	112	2.4	30	0.195
340	119	1.3	16	0.237

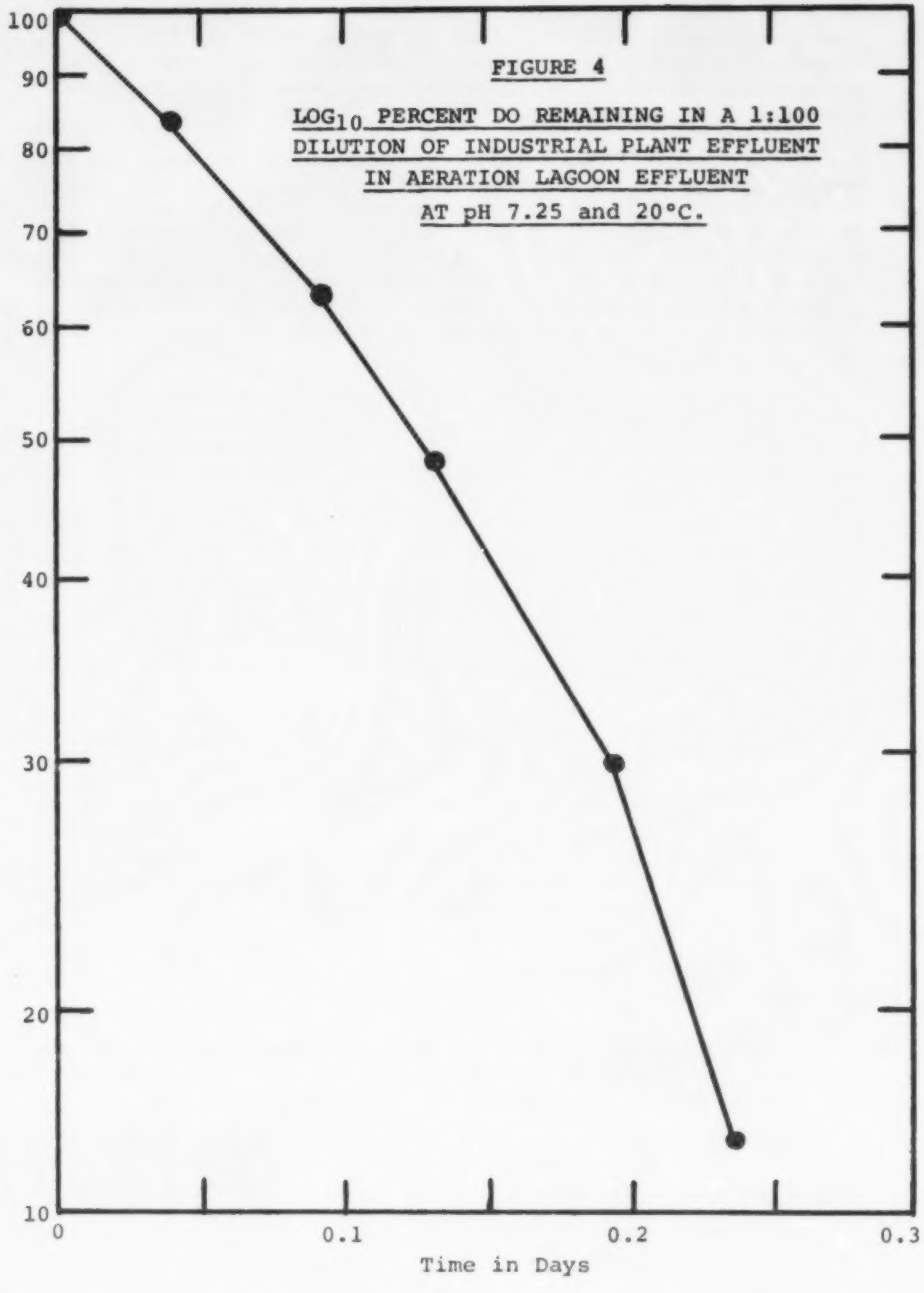


FIGURE 4

LOG_{10} PERCENT DO REMAINING IN A 1:100 DILUTION OF INDUSTRIAL PLANT EFFLUENT IN AERATION LAGOON EFFLUENT AT pH 7.25 and 20°C.

These experiments prompted an in vitro study of the behavior of mixtures of pure chlorophenol with the corresponding pure chlorophenoxy-acid when mixed in known concentration in aeration lagoon effluent.

One of the objectives of the project was to attempt to determine the rates of removal of chlorophenols and other related potentially toxic contaminants from the waste stream. Such determinations were not deemed practical if attempted directly on the constantly changing lagoon system. In the course of the work, however, the change in concentration of several chlorophenols in mixtures with corresponding chlorophenoxy-acids and aeration lagoon effluent was studied.

Several bottles of differing mixtures were maintained in conditions of continuous aeration at about 20°C by means of a common air supply. The air to each of the bottles was passed through a wash bottle containing distilled water to minimize loss of water from the various test bottles. Air flow was equalized to each bottle by adjustment of screw type pinch clamps, noting the number of bubbles of air. Each test bottle contained an equal volume taken from a "grab" sample of the aeration lagoon effluent. This sample was used as a common diluent and was collected in a five gallon bottle, aerated and stirred during removal of the quantity needed for each test bottle.

Known amounts of a chlorophenol and the corresponding phenoxy-acid were added to separate test bottles as solutions in distilled water. Each mixture was adjusted to pH 7.0 prior to mixture with the aeration lagoon effluent. In each instance, 50 ml of the neutral solution were added with stirring to make a final volume of two (2) liters in each test bottle. In this way the initial bacterial population and nutrients were as nearly identical as practicable. Blanks were prepared with 50 ml of each of four of the mixtures containing chlorophenols in distilled water only. These blanks were aerated to the same extent as the test bottles to determine the rate of vaporization of the chlorophenol.

The concentrations of the various compounds and the changes produced at various times following initial mixing are shown graphically in Figures 5, 6, 7, 8, 9 and 10.

A solution of technical pentachlorophenol was prepared to contain 1.586 gm/l by first dissolving the 'penta' in 0.5 normal sodium hydroxide and then diluting with distilled

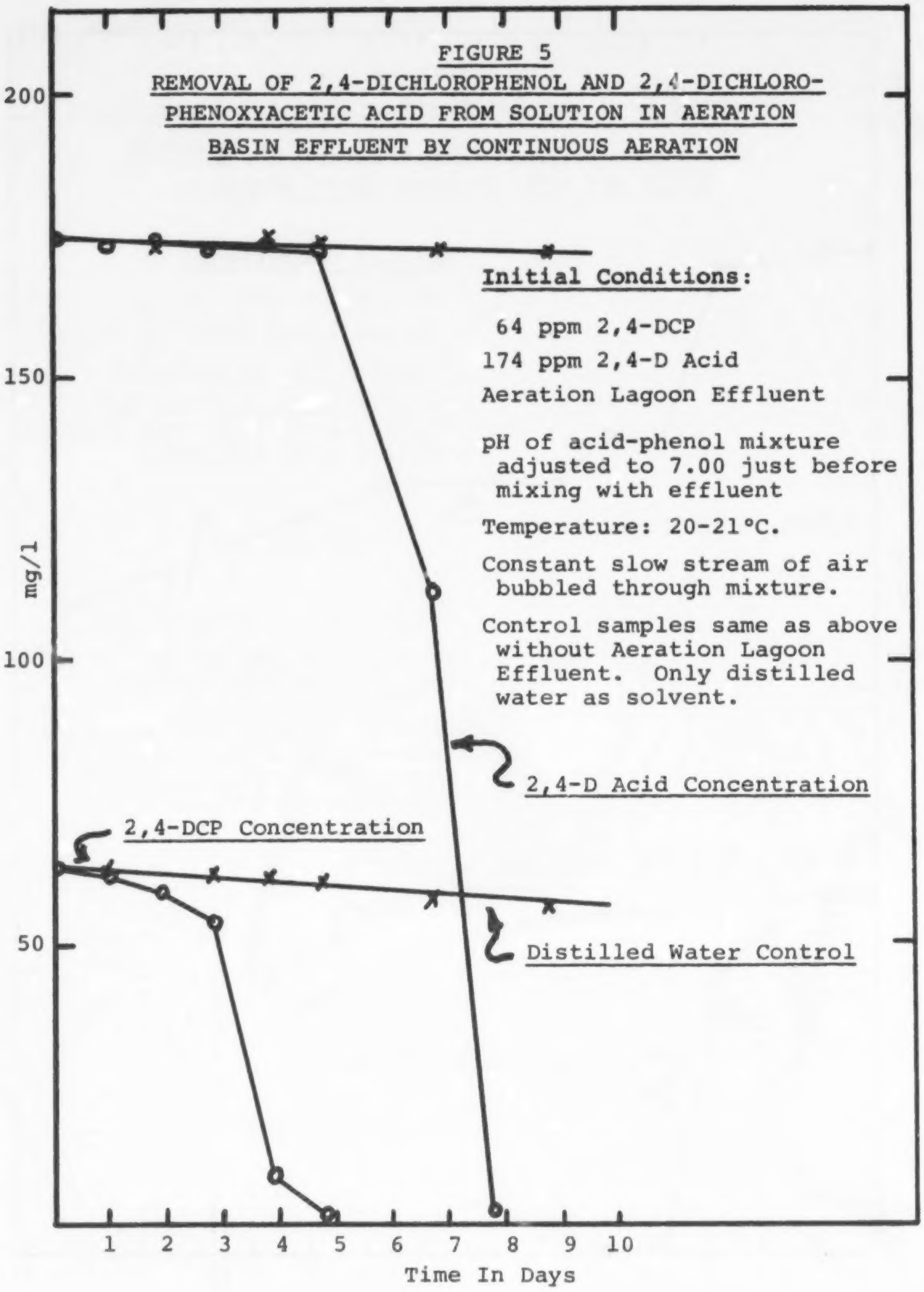


FIGURE 5

REMOVAL OF 2,4-DICHLOROPHENOL AND 2,4-DICHLOROPHENOXYACETIC ACID FROM SOLUTION IN AERATION BASIN EFFLUENT BY CONTINUOUS AERATION

Initial Conditions:

64 ppm 2,4-DCP

174 ppm 2,4-D Acid

Aeration Lagoon Effluent

pH of acid-phenol mixture adjusted to 7.00 just before mixing with effluent

Temperature: 20-21°C.

Constant slow stream of air bubbled through mixture.

Control samples same as above without Aeration Lagoon Effluent. Only distilled water as solvent.

200
150
100
50
mg/l
1
2
3
4
5
6
7
8
9
10
Time In Days
2,4-D Acid Concentration
2,4-DCP Concentration
Distilled Water Control

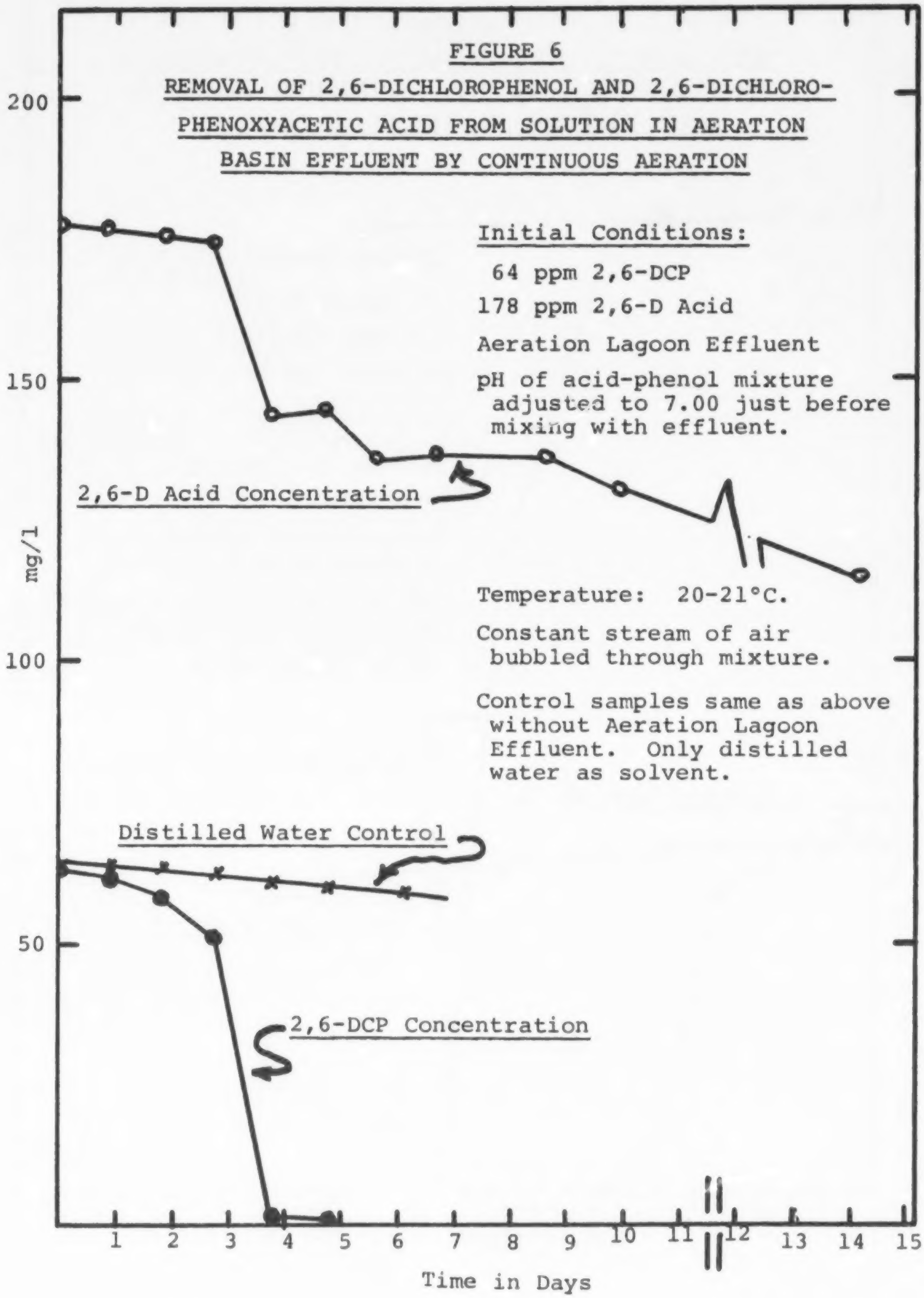


FIGURE 6

REMOVAL OF 2,6-DICHLOROPHENOL AND 2,6-DICHLOROPHENOXYACETIC ACID FROM SOLUTION IN AERATION BASIN EFFLUENT BY CONTINUOUS AERATION

Initial Conditions:

64 ppm 2,6-DCP

178 ppm 2,6-D Acid

Aeration Lagoon Effluent

pH of acid-phenol mixture adjusted to 7.00 just before mixing with effluent.

Temperature: 20-21°C.

Constant stream of air bubbled through mixture.

Control samples same as above without Aeration Lagoon Effluent. Only distilled water as solvent.

200
150
100
50
mg/1
2,6-D Acid Concentration
Distilled Water Control
2,6-DCP Concentration
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Time in Days

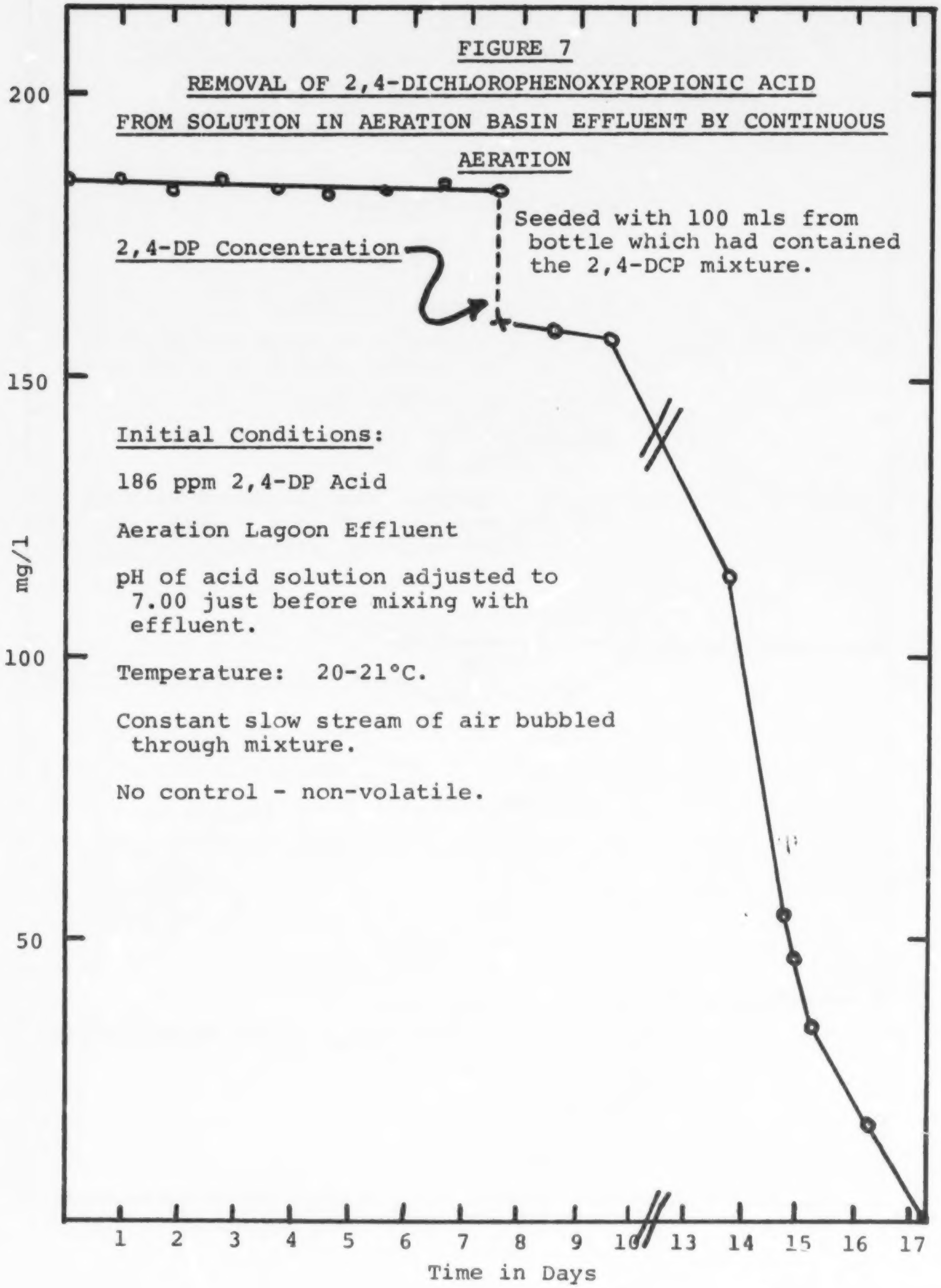


FIGURE 7

REMOVAL OF 2,4-DICHLOROPHENOXYPROPIONIC ACID FROM SOLUTION IN AERATION BASIN EFFLUENT BY CONTINUOUS AERATION

Seeded with 100 mls from bottle which had contained the 2,4-DCP mixture.

2,4-DP Concentration

Initial Conditions:

186 ppm 2,4-DP Acid

Aeration Lagoon Effluent

pH of acid solution adjusted to 7.00 just before mixing with effluent.

Temperature: 20-21°C.

Constant slow stream of air bubbled through mixture.

No control - non-volatile.

200
150
100
50
mg/l
1
2
3
4
5
6
7
8
9
10
13
14
15
16
17
Time in Days

FIGURE 8

REMOVAL OF 2,4,5-TRICHLOROPHENOL AND 2,4,5-TRICHLOROPHENOXYACETIC ACID FROM SOLUTION IN AERATION BASIN EFFLUENT BY CONTINUOUS AERATION

Initial Conditions:

50 ppm 2,4,5-T Acid
18.8 ppm 2,4,5-TCP

Aeration Basin Effluent

pH of acid-phenol mixture adjusted to 7.00 just before mixing with effluent.

Temperature: 20-21°C.

Constant slow stream of air bubbled through mixture.

Control samples same as above without Aeration Basin Effluent. Only distilled water as solvent.

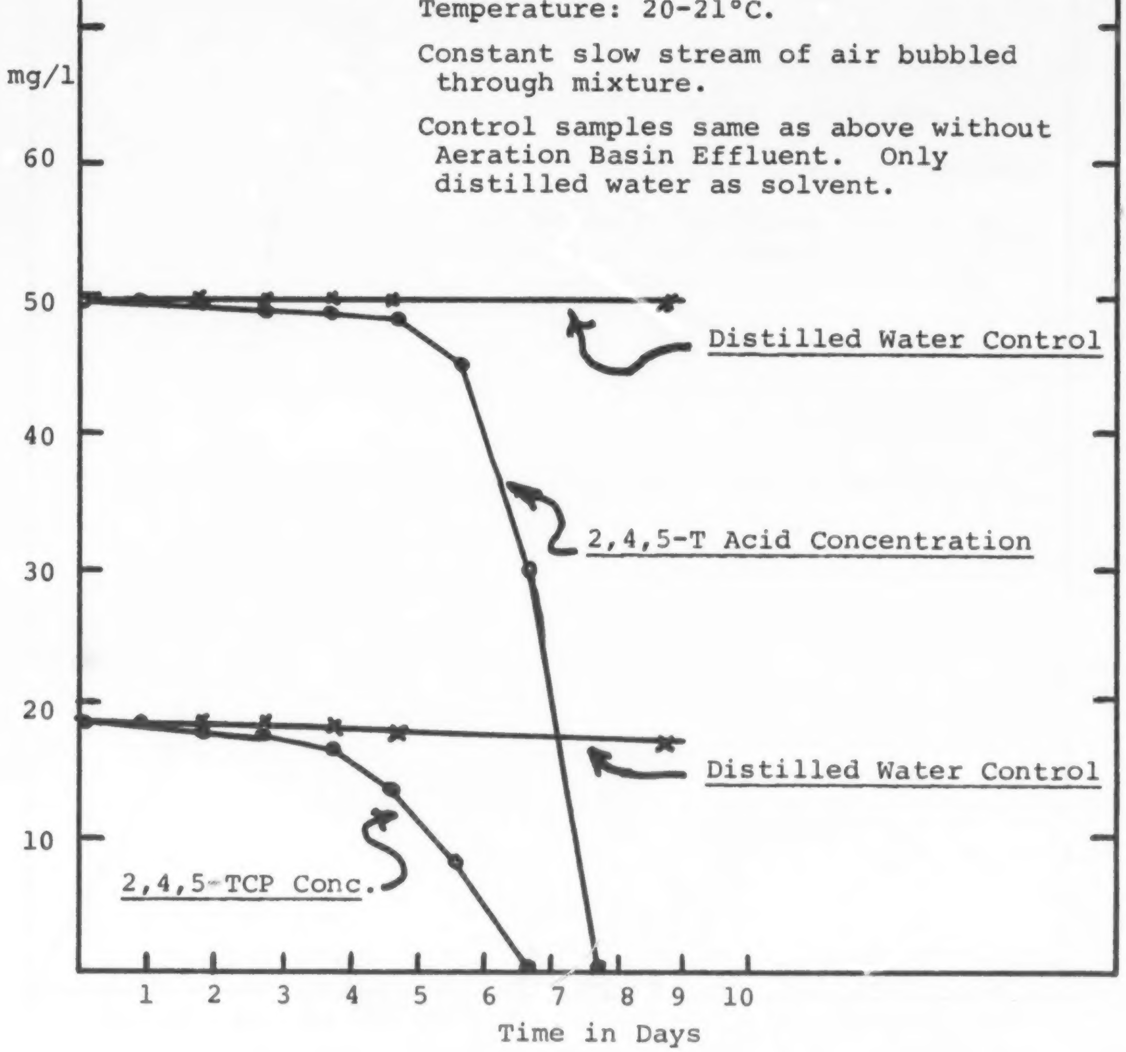
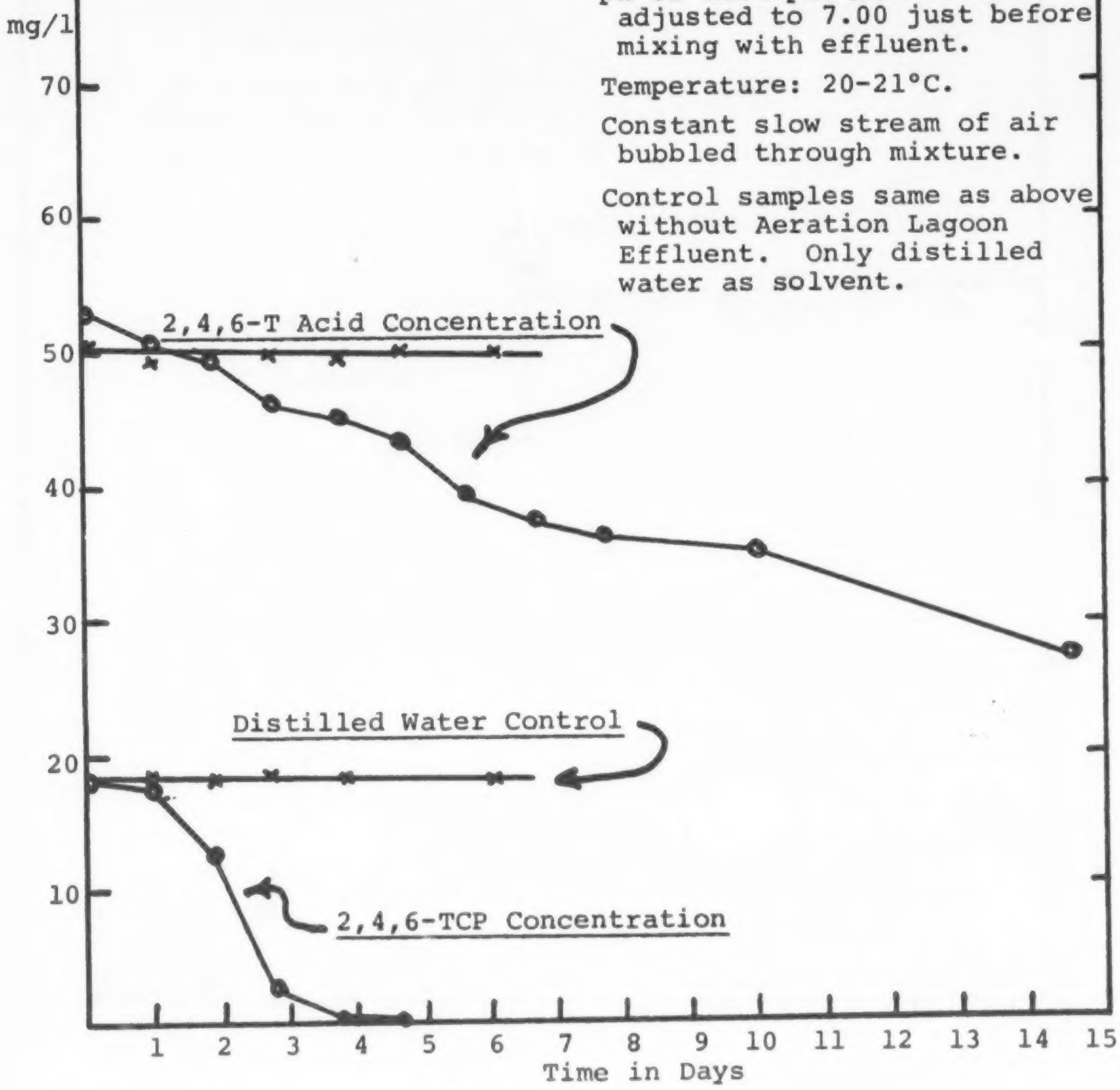


FIGURE 9

REMOVAL OF 2,4,6-TRICHLOROPHENOL AND 2,4,6-TRICHLOROPHENOXYACETIC ACID FROM SOLUTION IN AERATION BASIN EFFLUENT BY CONTINUOUS AERATION



Initial Conditions:

18.5 ppm 2,4,6-TCP

53.0 ppm 2,4,6-T Acid

Aeration Lagoon Effluent

pH of acid-phenol mixture adjusted to 7.00 just before mixing with effluent.

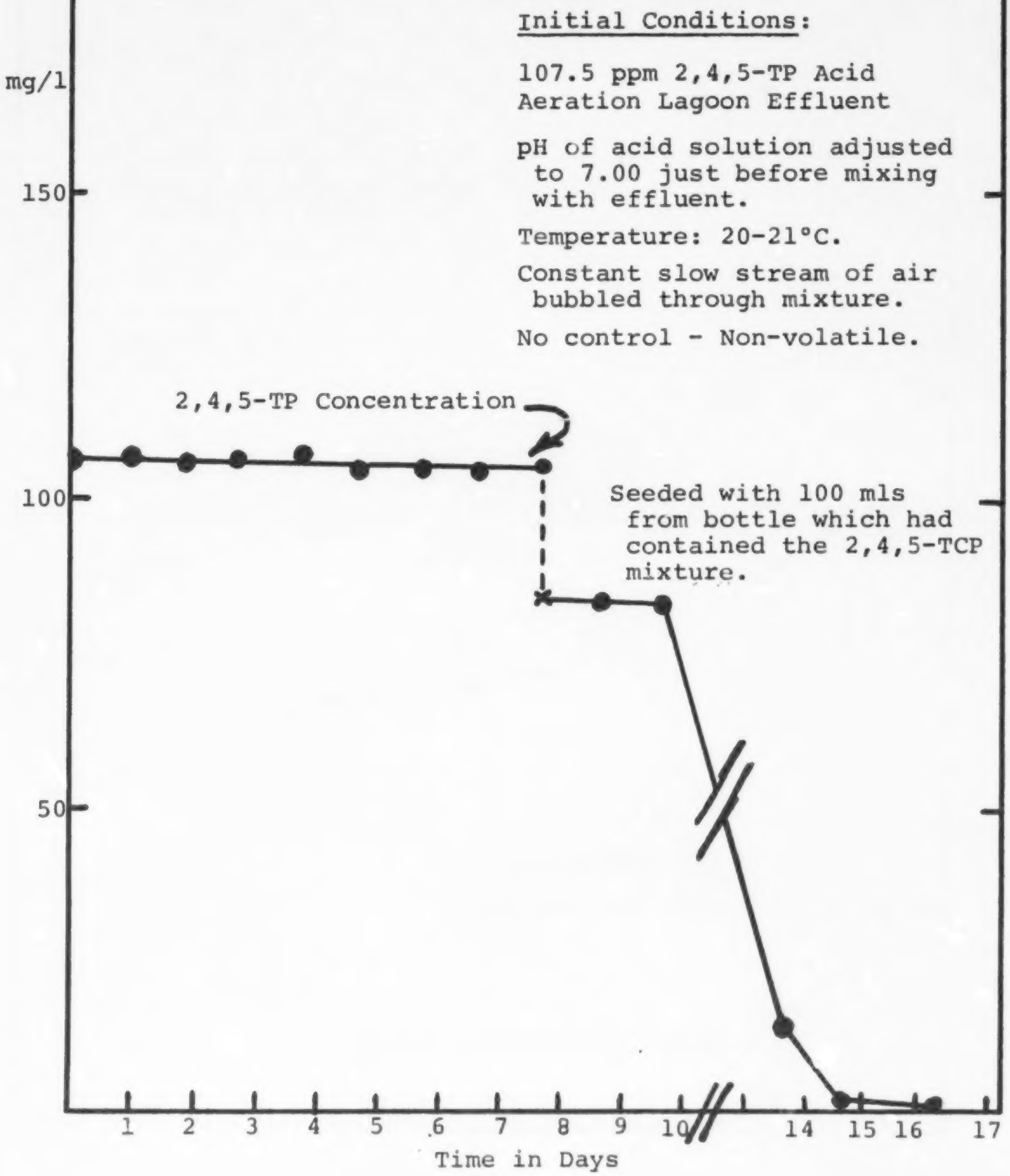
Temperature: 20-21°C.

Constant slow stream of air bubbled through mixture.

Control samples same as above without Aeration Lagoon Effluent. Only distilled water as solvent.

FIGURE 10

REMOVAL OF 2,4,5-TRICHLOROPHENOXYPROPIONIC ACID FROM SOLUTION IN AERATION BASIN EFFLUENT BY CONTINUOUS AERATION



Initial Conditions:

107.5 ppm 2,4,5-TP Acid
Aeration Lagoon Effluent

pH of acid solution adjusted to 7.00 just before mixing with effluent.

Temperature: 20-21°C.

Constant slow stream of air bubbled through mixture.

No control - Non-volatile.

water. A portion of this solution was used to prepare two liters of a mixture with aeration lagoon effluent to contain 39.5 mg/l of pentachlorophenol. The mixture was aerated continuously and samples were removed for analysis at intervals. At this concentration the pentachlorophenol appeared to be in solution, but the mixture was shaken thoroughly before taking each sample to ensure uniformity. The results obtained are shown in Table XXX under Experiment 1. No significant change occurred up to the time the aerated mixture was seeded with a portion of aeration lagoon influent as noted in the Table. Thereafter, by the third day the concentration of pentachlorophenol was reduced to 0.5 mg/l.

A second mixture containing about 81 mg/l of pentachlorophenol was prepared using aeration lagoon influent. This mixture was aerated continuously and sampled for analysis. The data obtained is shown in Table XXX under Experiment 2. As in the first experiment with 'penta' in aeration lagoon effluent, little change in concentration occurred until the mixture was seeded with a portion of mixed liquid from the first experiment. Then in 30 hours the concentration fell to 0.6 mg/l.

A third experiment employing 1440 ml of the residual liquid from the second experiment made up to a total volume of 1640 ml with BOD dilution water and neutralized pentachlorophenol solution. This mixture, having an initial concentration of about 81 mg/l of pentachlorophenol, was aerated continuously and sampled for analysis as before. The results obtained are shown in Table XXX under Experiment 3. This mixture lost pentachlorophenol smoothly until a level of about 9 mg/l was reached, at which time it was noted that the pH of the mixture had dropped to 5.2 and change had ceased.

The data given in Table XXX is plotted in Figure 11 to illustrate the changes graphically. In figure 12, the $\log_{10}$ of the amount of pentachlorophenol which had disappeared in Experiment 3 is plotted versus time.

TABLE XXX

CHANGE IN PENTACHLOROPHENOL CONCENTRATION IN AERATED SOLUTIONS IN AERATION LAGOON EFFLUENT

Experiment 1		Experiment 2	
Time (Days	Concentration (mg/l)	Time (Days)	Concentration (mg/l)
0	40.3	0	81.1
0.8	38.9	0.25	80.0
2.8	39.8	1.04	77.9
3.8	40.4	1.47	78.5
4.8	39.6	1.94	79.3
7.7	38.1	5.13	74.3
		6.0	74.1
Seeded with 100 mls Aeration Lagoon Influent at 7.70 days (100 mls + 1475 mls)		6.4	75.8
		Seeded with 150 mls of Experiment 1 (150 mls + 1529 mls)	
0	35.6		
1.0	32.0		
2.0	17.1	0	62.3
3.0	0.5	1.25	0.6

Experiment 3

Residue from Experiment 2 with added 'Penta'

Time (Days)		Concentration (mg/l	Amount Disappeared (mg/l)
0	pH 7.1	81.5	0
0.97		70.3	11.2
1.09		67.4	14.1
1.26		63.9	17.6
1.61		53.0	28.5
1.96		38.6	42.9
2.24		21.1	60.4
2.45		9.75	71.75
2.95	pH 5.2	8.82	72.68
3.28		8.85	72.65

FIGURE-11

CHANGE IN PENTACHLOROPHENOL CONCENTRATION IN AERATED SOLUTIONS IN AERATION LAGOON EFFLUENT

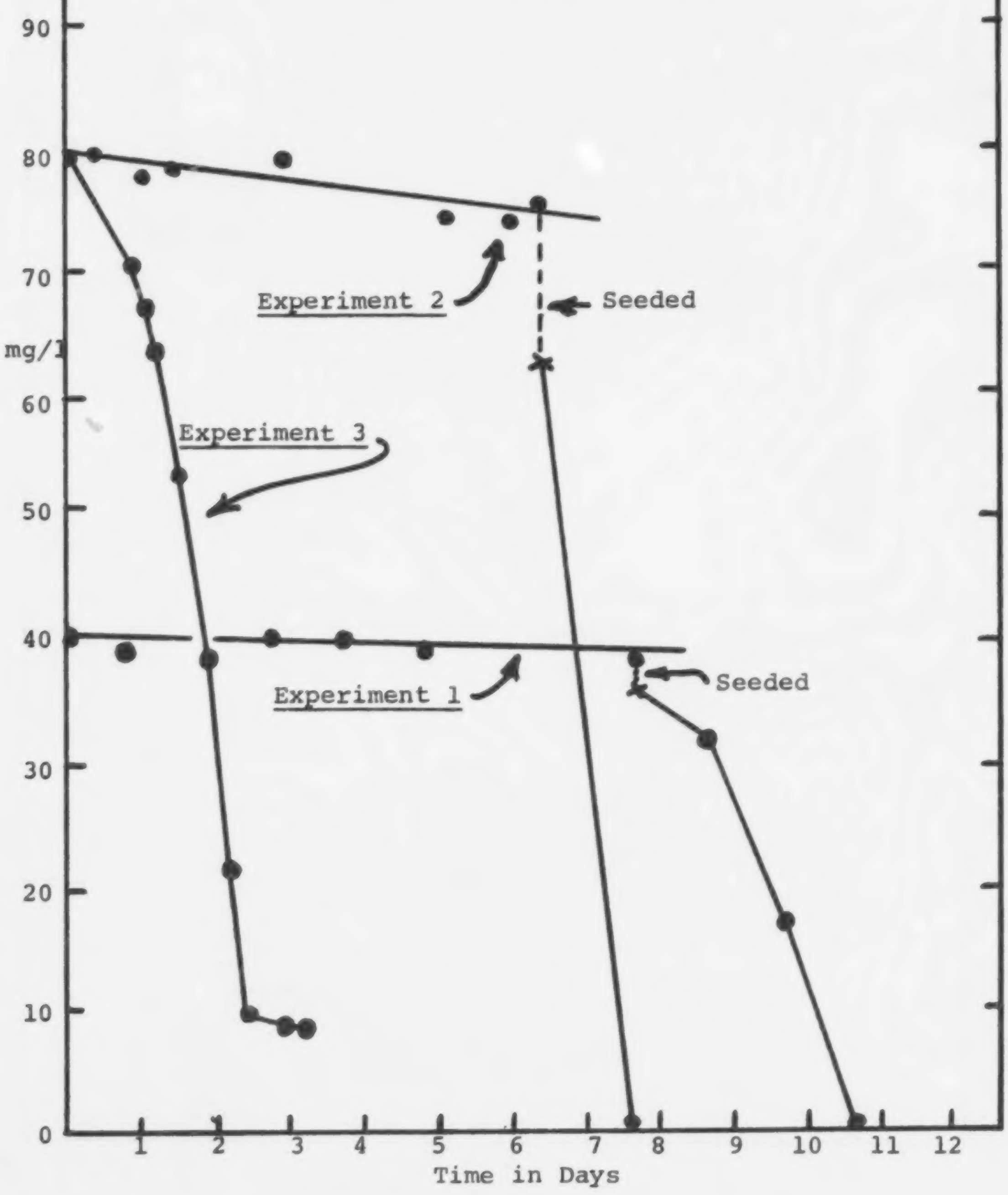
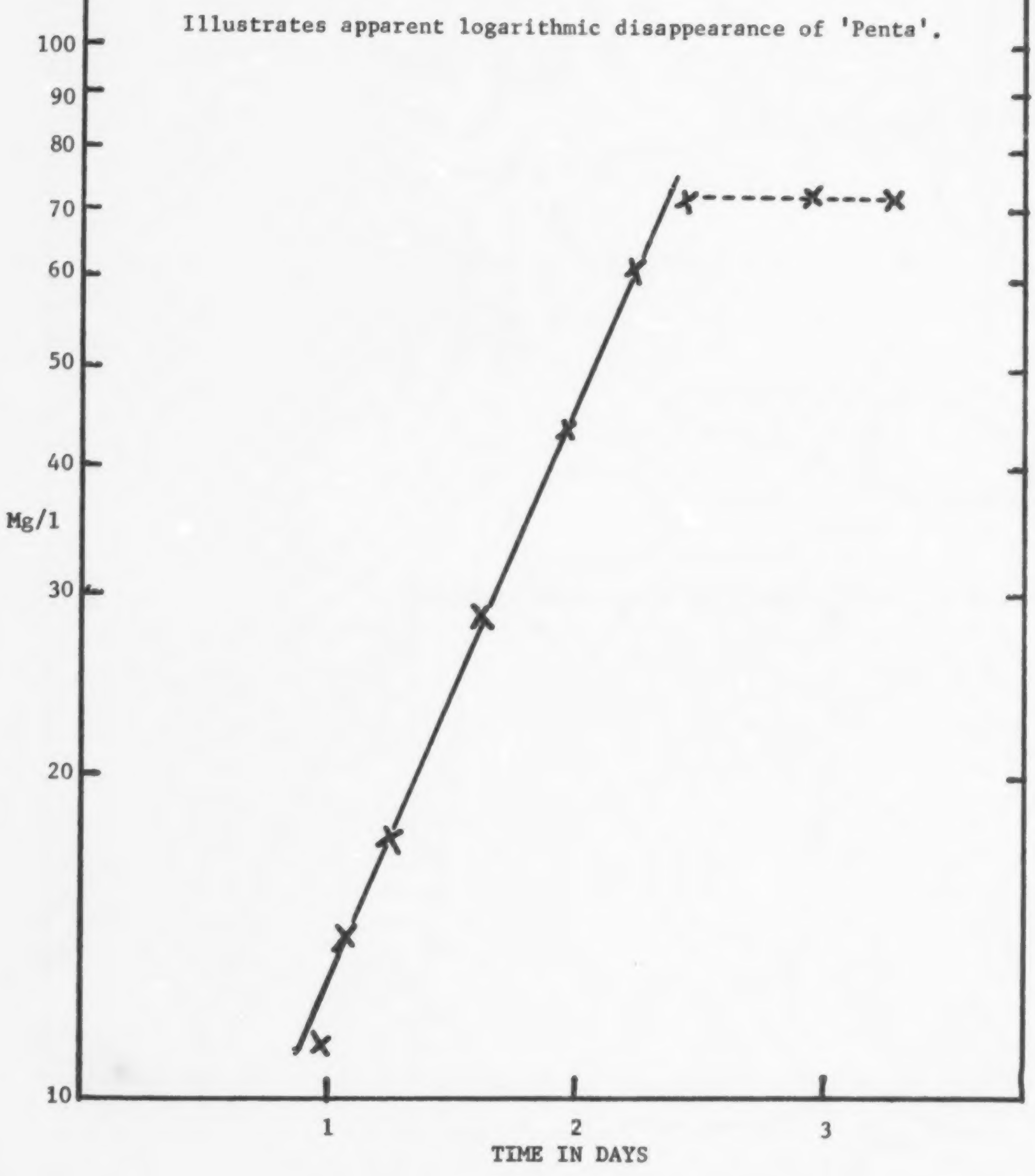


FIGURE 12

LOG PLOT OF PENTACHLOROPHENOL CONCENTRATION REACTED
VERSUS
TIME IN DAYS FOR EXPERIMENT No. 3 WITH 'PENTA'



Illustrates apparent logarithmic disappearance of 'Penta'.

SECTION IX

BIOLOGICAL STUDY

Time Period Covered:

Biological sampling and analyses were carried out during the period of June 6, 1969, until June 29, 1970. A total of 100 samplings at each of 12 sample points was made during this time, which included four seasonal intensive sampling periods of two weeks each, during which samples were taken at all sampling points each day. At other times weekly samples were taken at all twelve points.

Sampling Procedure:

Aeration Lagoon: The aeration lagoon or basin was sampled at the influent and effluent on each sampling day, and water temperature, pH, and dissolved oxygen measured at both points. The influent and effluent were designated Station 1 and Station 2, respectively. Samples of the algae growing on the aeration basin rocks were taken on a random basis.

Oxidation Lagoons: Five samples were taken at each oxidation lagoon or pond during each sampling day: four at grid points, and one at each effluent (see diagram of sampling point locations, Fig. B-1). Water temperature, pH, and dissolved oxygen were determined, as were those of the aeration lagoon, when samples were taken. Air temperatures were also recorded on sampling days, and all samples analyzed for total and fecal coliform bacteria and for plankton organisms. Intermittent bottom sampling produced virtually no benthic organisms.

Methods of Analysis:

Plankton: Plankton samples were obtained by means of a small plastic bucket. Whenever possible, plankters were counted immediately upon return to the laboratory, unpreserved. Whenever it was necessary to preserve plankton samples for counting at a future date, this was done by adding 10% formalin adjusted to pH 7.0 with borax powder. Plankton samples were concentrated in the largest quantities practicable - usually from 25 to 100 ml - by passing the water through a membrane filter (Millipore type HA) of pore size 0.45 u.

BIOLOGICAL STUDY
SAMPLING POINT LOCATIONS
OCTOBER, 1970

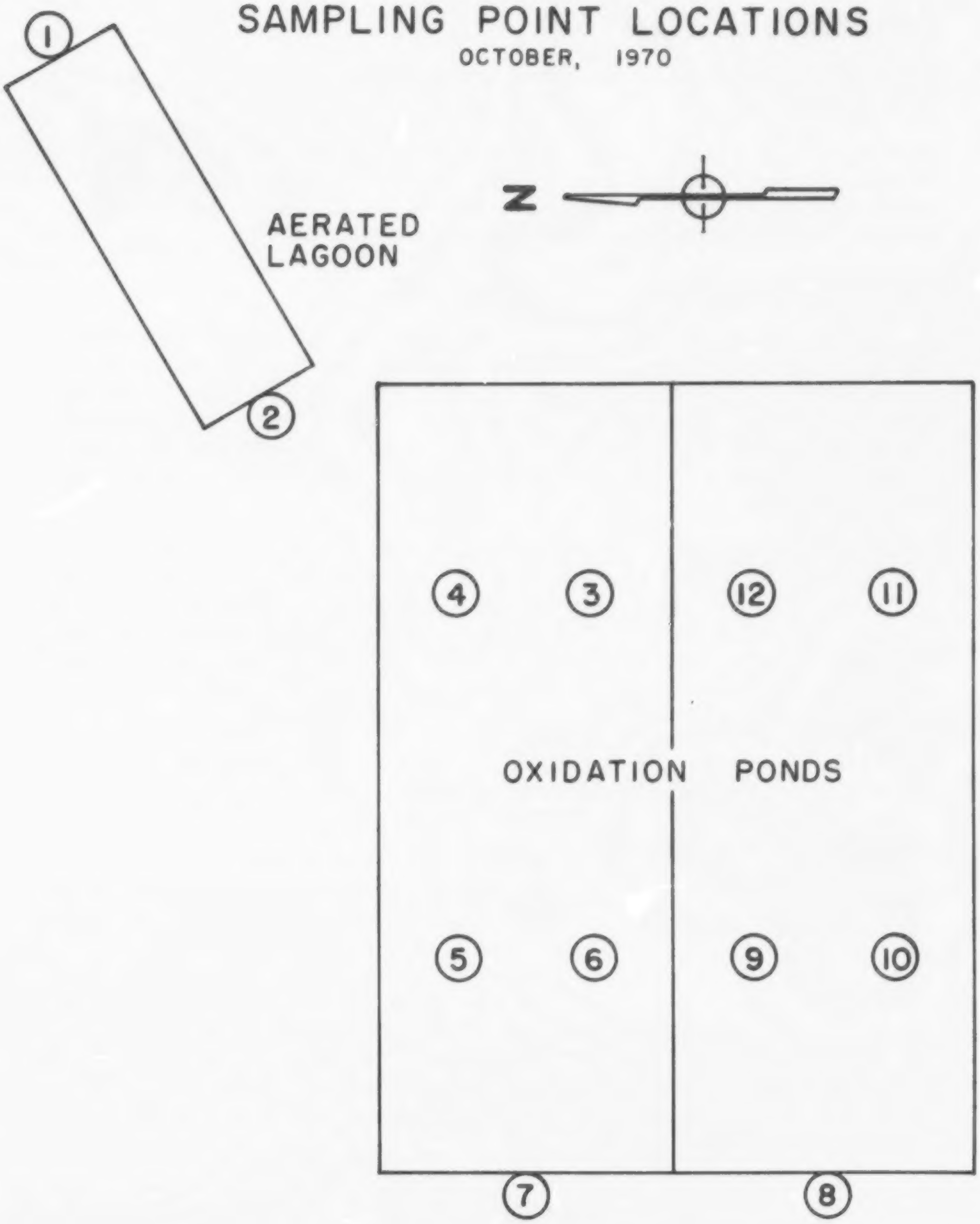

①
AERATED
LAGOON
N
②
④
③
⑫
⑪
OXIDATION PONDS
⑤
⑥
⑨
⑩
⑦
⑧

FIG. B-1

Plankters were identified and counted by using a Sedgwick-Rafter all-glass counting chamber and binocular microscope. Total chamber counts were made, and the appropriate concentration factors applied in order to determine the number of organisms per liter. Since there was no significant difference in the kinds and numbers of plankters found at the various grid sampling points of the oxidation ponds, the mean of the numbers of plankters at these points was used as the "Body of Oxidation Ponds" station of the plankton graphs (Fig. B-3). Plankters examined in the samples covered by this report reveal that these organisms were few in generic types, and are in general those types normally associated with sewage lagoons. Appendix A presents averages per liter of each of the plankton genera identified at each station during the non-intensive sampling periods.

Organisms Growing on Aeration Basin Rocks:

Four genera of plankton organisms predominated on the stones of the aeration basin levees: Phormidium, Ulothrix, Anacystis, and Navicula. Of these, Anacystis is consistently the more numerous, followed by the others in the order in which they are listed above. Phormidium and Anacystis are blue-green algae and pollution-tolerant, Ulothrix is a green alga and pollution-tolerant, and Navicula is a diatom which is also pollution-tolerant. When they are operating, the trickling filters of the old portion of the sewage treatment plant have organisms of these four genera growing on their rocks. The numbers of individuals of each of these genera, in both trickling filters and aeration stones, varies somewhat with the seasons of the year.

Microbiological Sampling and Analyses: Counts of total coliform bacteria and bacteria of the fecal coliform group were made for each sample taken at each sampling station. There proved to be no significant difference in the number of coliform organisms found at the various grid sampling points of the oxidation lagoons; therefore, the mean of the numbers of coliforms at these points was used in obtaining the "Body of Oxidation Ponds" station point B of Fig. B-2. Microbiological technics employed in treating these samples were as follows:

1. Total Coliform Bacteria: Total coliform counts were obtained by the membrane filter method. Type HA Millipore filters with a pore size of 0.45 u were used. Three filtrations of each sample (0.1, 1.0, and 10.0 ml) were

made, and the stainless steel filtration funnel rinsed three times following filtration with 10-20 ml of phosphate-buffered distilled water, while the membrane was still in place.

All membrane filters were rolled on to blotter-type filter pads saturated with m-ENDO BROTH MF (Difco), rehydrated by using 100 ml distilled water and 2.0 ml ethyl alcohol for each 4.8 gm of the dried medium. Filters were incubated on their pads for 22-24 hr. at 35°C ± 0.5°C in the inverted position (in order to prevent the accumulation of water on the surface of the membrane filter). The average number of coliform organisms per 100 ml of sample water was obtained by noting the number of colonies (exhibiting a golden sheen) that grew during each incubation, converting this to numbers per 100 ml, then averaging the three in order to obtain the average number per 100 ml in the sample.

2. Fecal Coliform Organisms: Counts of fecal coliform organisms were obtained in a manner similar to that employed for total coliforms, with notable exceptions. In brief, the method used was as follows. Difco mFC BROTH BASE was used, and the medium rehydrated by suspending 3.7 grams in 100 ml distilled water. Following rehydration, one ml of a 1% solution of rosolic acid in 0.2N sodium hydroxide was added. The solution was heated to boiling, cooled to room temperature, and each absorbent pad saturated with the medium as in the total coliform procedure (approximately 2 ml per pad). After saturation, excess medium in each petri dish was discarded. Each pad and membrane were encased in a plastic petri dish with tight-fitting cover, or several petri dishes were enclosed in a water-tight plastic bag, and incubation carried out by submerging the dishes in the inverted position in a water bath maintained at a temperature of 44.5°C ± 0.5°C for 24 hours. Dark blue colonies are indicative of fecal coliform organisms, and averages per 100 ml are obtained as in the method for enumerating total coliform bacteria. Averages of total and fecal coliform counts for each station are presented in Tables B-1, B-3, B-5, and B-6 (see Appendix B). The data in Appendix B reflect relevant items in Fig. B-2, which shows the numbers of total and fecal coliform organisms at the influent of the aeration basin, the body of the oxidation lagoons, and the effluents of these lagoons, during each of the four seasonal intensive studies.

pH: Determination of pH was made immediately upon sampling by employing a Hach Model 1975 battery-operated pH meter, calibrated frequently by means of standard buffers.

Dissolved Oxygen and Water Temperature: Dissolved oxygen in parts per million and temperature of the water (and air) in degrees centigrade were obtained as soon as each sample was taken, by means of a Model 54 Oxygen Meter (battery operated), manufactured by the Yellow Springs Instrument Company. The meter was calibrated periodically against the Winkler method for the determination of dissolved oxygen.

EXPLANATION OF TABLES

Following this discussion, twelve tables are presented which summarize the biological work carried out during this survey at the Jacksonville, Arkansas, sewage treatment plant: Tables B-1 through B-8 summarize water temperatures, pH, dissolved oxygen, total and fecal coliform organisms, and kinds and numbers of plankters found during the intensive sampling periods. Tables B-9 through B-12 summarize the bacteriological and physical data accumulated during the entire survey, presenting maximums, minimums and averages for the parameters measured.

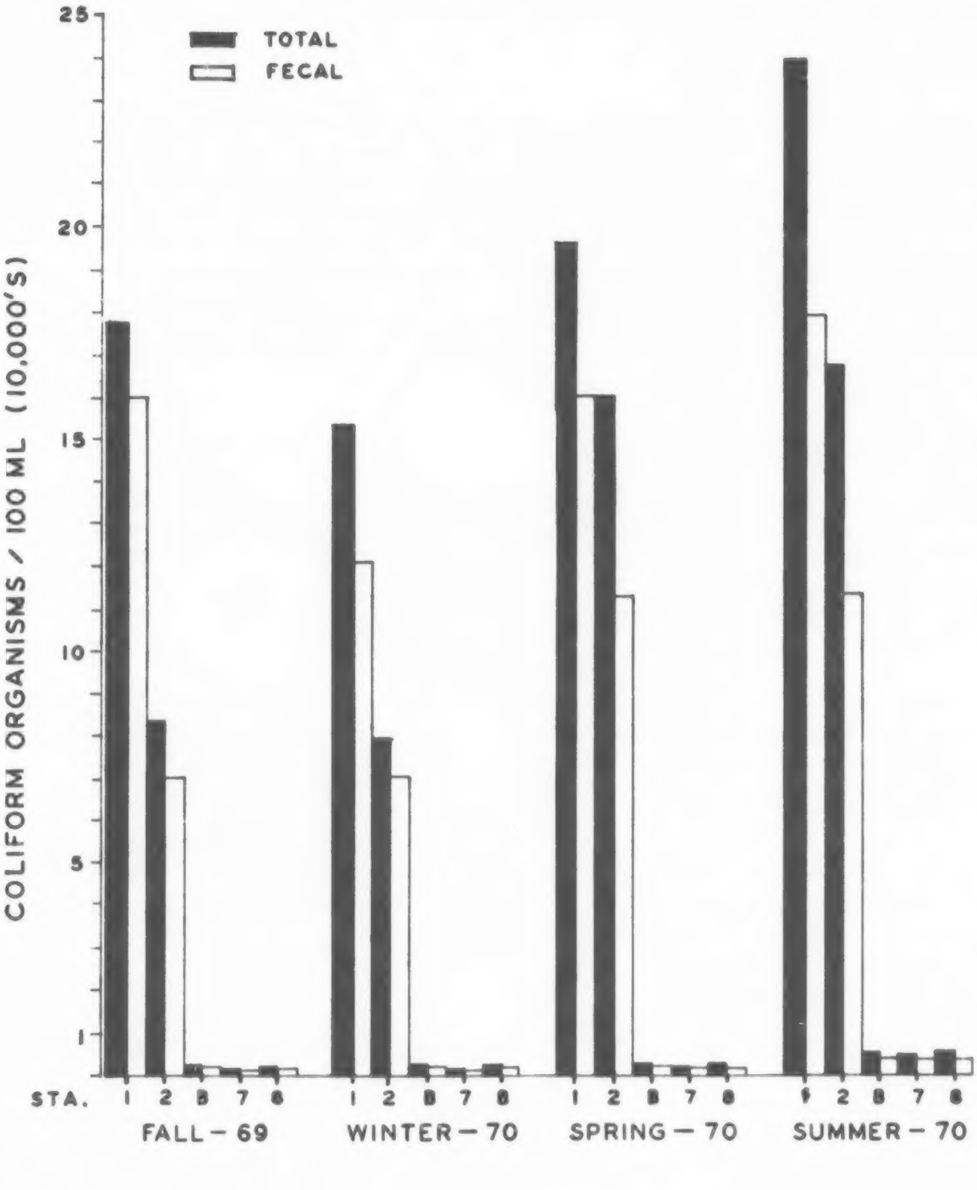
Discussion and Conclusions:

The information gathered in the biological portion of this study indicates that the general conditions prevailing in the Jacksonville treatment plant do not differ in any significant way from conditions to be expected in a similar setup that does not receive complex chlorophenolic wastes combined with the normal sewage.

As seen in Figure B-3, a conventional pattern of plankton growth occurred both in time and space. A low level of plankton growth occurred in the aeration pond influent, with a slight increase in the effluent, and a large increase in the body of the ponds. The characteristic pattern of increasing spring plankton populations followed by peak summer blooms, decreasing in autumn to a winter low, occurred at all points except No. 2, the aeration lagoon effluent, where an uncharacteristic dip occurs in the summer population. Since this anomaly was not reflected in the body of the oxidation ponds, it is doubtful that it is of any real significance; rather it is more probably the result of inconsistent counting practices, chiefly involving the ubiquitous blue-green algae *Anacystis*, which is quite difficult to count.

FIGURE 8-2

COLIFORM ORGANISMS
SEASONAL INTENSIVE STUDIES



The reduction in coliform organisms across the system is quite good, as shown in Figure B-2. The general picture of coliform density also adheres quite closely with what one would expect in a similar normal system, with high summer counts, low winter counts, and intermediate spring and fall counts.

The Hercules plant was shut down during much of the time period covered by this study. Interpretations of the data in relation to the subject of this research project is, therefore, quite difficult. The plant was in operation during only 23% of the biological study period, and most of this occurred during the last five months. The plant operated only 7% of the days during the first eight months, while it operated 50% of the days of the final five months. Figure B-4 shows the periods of operation during the thirteen months of the study, and also shows the intensive seasonal studies in relation to the periods of plant operation. The plant did not operate at all during the fall intensive and had not operated for nearly four months prior to it. The plant did not resume operations until near the end of the winter intensive. On the other hand, Hercules operated fairly regularly before and during the spring and summer intensive studies. In spite of these facts, nothing could be found in the data which would indicate that the biological aspects of the ponds were influenced in any significant way by the immediate presence or absence of waste from the Hercules plant in the influent.

SEASONAL VARIATIONS IN NUMBERS OF PLANKTON IN AERATION LAGOON INFLUENT AND EFFLUENT AND IN BODY OF OXIDATION PONDS

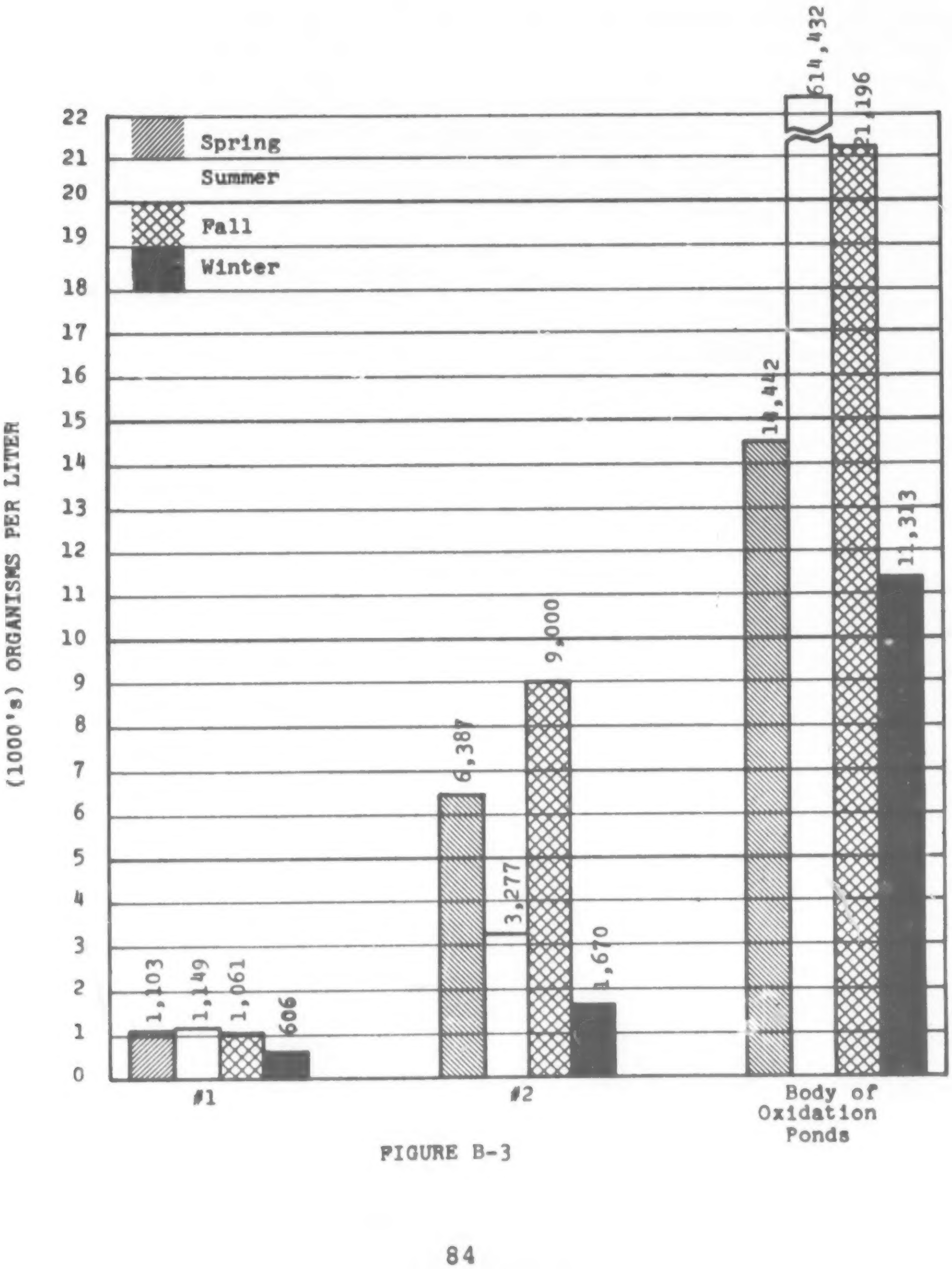
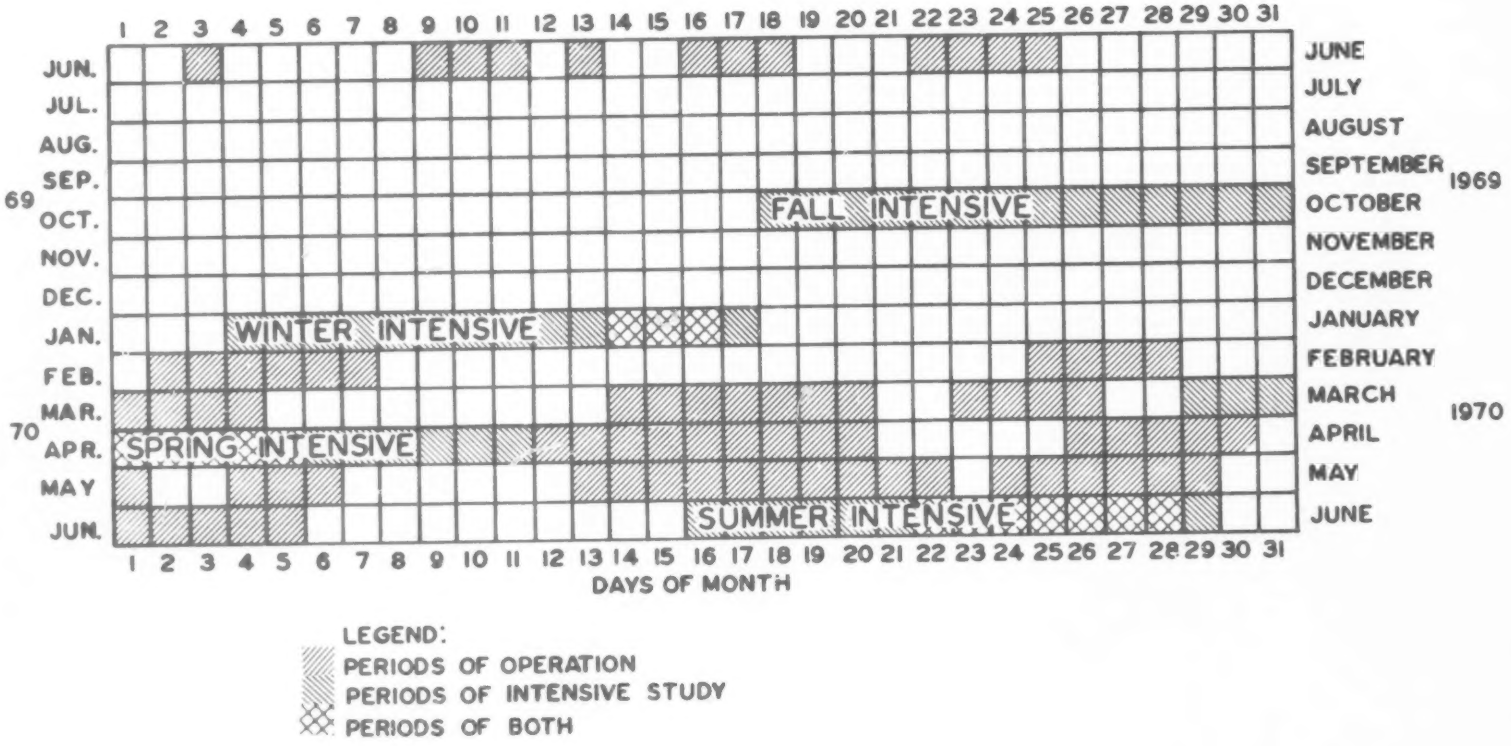


FIGURE B-3

FIGURE B-4

PERIODS OF HERCULES, INC. PLANT OPERATION SHOWING RELATIONSHIP TO SEASONAL INTENSIVE BIOLOGICAL STUDIES



SECTION X

COST ANALYSIS

Installation:

The cost of installation of the pump station revisions, force main, aerated lagoon and appurtenances as designed for the joint treatment of herbicidal-domestic wastes in the modified Jacksonville west sewage treatment plant are presented here as a matter of record. Obviously, the costs of such an installation at other locations will vary from these costs with the treatment requirements of a particular municipality, construction costs in the area and the availability and cost of the necessary land. However, the costs presented should serve as the basis for an order of magnitude estimate.

Cost of Construction:

Compacted Fill:	$ 13,764.80
Class "A" Concrete:	3,802.50
Class "B" Concrete:	731.25
Reinforcing Steel:	750.00
Sewer Pipe:	8,533.00
Crushed Stone:	2,125.00
Gravel Cut and Replaced:	85.00
Lump Sum Items (Electrical, Fencing, Clearing, Etc.):	34,673.60
Aeration Equipment:	65,987.00
Engineering:	11,965.39
Total:	$142,417.54

Operation:

The principal cost of operation of an aerated lagoon is that of electrical power for the pumps and aerators. This cost also will vary with the location because of different power rate structures and with the requirements of a particular municipality.

During one year, from May 16, 1969 to May 15, 1970 inclusive, one billion gallons of sewage flowed through the aeration lagoon. This represents an average flow of 83.3 million gallons per month or 2.74 MGD. The cost of power for the aerators during that period was $16,289.17. The average cost per month was $1,357.43 or $44.63 per day. Thus, the sewage was aerated at an average cost of 1.63 cents per thousand gallons.

The total BOD_5 load on the aeration lagoon, based on an average BOD_5 content of the influent of 77 mg/l, was 639,100 pounds.

The total BOD_5 content of the effluent, based on an average BOD_5 content of 25 mg/l, was 208,250 pounds.

The BOD_5 satisfied by up-take of oxygen in the aeration lagoon was therefore 430,850 pounds of BOD_5, removed at a cost of 3.78 cents per pound.

SECTION XI

DISCUSSION

The industrial waste under study in this joint treatment project arises from the manufacture of hormone type herbicides, principally 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T). The former is made by coupling 2,4-dichlorophenol (2-4-DCP) with monochloroacetic acid (MCA) in alkaline medium, the latter by employing 2,4,5-trichlorophenol (2,4,5-TCP) in place of 2,4-DCP.

The interaction of chlorine gas bubbled into dry molten phenol contained in a glass system, maintained at nearly constant temperature slightly above 50°C, proceeds readily without a catalyst as an exothermic reaction evolving hydrogen chloride. Chlorine replaces hydrogen in phenol most readily in the 4- position, less readily in the 2- position. As chlorination is continued, both 2- and 4- chlorophenol may yield 2,4-DCP and 2-chlorophenol may yield 2,6-dichlorophenol (2,6-DCP). By the time 2 molar equivalents of chlorine per mol of phenol have been added, a small amount of 2,4,6-trichlorophenol (2,4,6-TCP) may be present. Further chlorination yields more 2,4,6-TCP readily at the expense of the 2,4-DCP and 2,6-DCP compounds, but little higher chlorination occurs without higher temperature and added catalyst.

Technical dichlorophenol thus may consist of from 86-92% of 2,4-DCP with 11 - 6% of 2,6-DCP and variable small amounts of 2-chlorophenol and 4-chlorophenol (if underchlorinated) and 2,4,6-TCP (if slightly overchlorinated).

Technical 2,4,5-TCP is not a product of direct chlorination and may contain small amounts of 2,5-dichlorophenol (2,5-DCP) and other materials depending on conditions of manufacture. 2,4,5-TCP is produced by alkaline dechlorination of 1,2,4,5-tetrachlorobenzene, which may contain small amounts of 1,2,4-trichlorobenzene. The latter compound yields 2,5-DCP upon dechlorination in the process used.

Thus the neutral aqueous waste stream from a plant using technical 2,4-DCP and technical 2,4,5-TCP to produce chlorophenoxy acid based herbicides would be expected to have a variable mixed chlorophenol content. A greater content of 2,6-DCP would be expected in the waste stream because 2,4-DCP appears to couple with MCA nearly five times as rapidly as does 2,6-DCP. The waste stream would also exhibit a variable content of the salts of various chlorophenoxy-acids and of the highly water soluble, by-product hydrolysate salts of the chloroalkanoic acids used in the manufacturing process. A relatively high concentration of salts of the mineral acid used to liberate the organic acids in the process would be expected as the major constituent of the waste.

Mills$^{(1)}$ reported on the removal of "dichlorophenol" present in a 2,4-D waste water stream using a pilot plant designed as a combined trickling filter and activated sludge system. The pilot plant unit was seeded with activated sludge from a local sewage plant and the waste stream was diluted to one-tenth strength with water before treatment. He states that the average removal of "dichlorophenol" during the most efficient period of operation was 86%. It is assumed that the "dichlorophenol" present in the waste studied by Mills was comparable to the complex chlorophenol mixture encountered in the present study, although the mineral acid salt content may have been different.

It was demonstrated that the nature of the industrial waste studied here did not change significantly during the time between the special survey of the Upper Bayou Meto by the Arkansas Pollution Control Commission, as shown in quoted Table I and the time of the demonstration project. However, the magnitude of the waste components did change from time to time during the project as noted in Table XXI. These changes were brought about by intermittent operation of the plant and improved in-plant recovery processes.

During the first four months of this study of joint treatment, a period of minimal industrial plant activity, the average reductions in BOD_5, COD and chlorophenols across the aeration lagoon and stabilization ponds were found to be 87%, 77% and 92%, respectively, for unfiltered samples.

Removal of chlorophenols by the aerated lagoon alone during the period of industrial plant operation ranged from 55 to 89%, while the overall removal of chlorophenols by both the lagoon and stabilization ponds ranged from 87 to 94%. Removal of chlorophenoxy acids was definitely less, ranging from about 30 to 70% within the lagoon, while removal by the lagoon and ponds ranged from 49 to 80%.

However, the stabilization pond effluent quality during this period was good: The average unfiltered BOD_5 was 15 mg/l; chlorophenols, 0.1 mg/l; and chlorophenoxy acids, 1.1 mg/l. Chloride climbed to a peak of about 540 mg/l, which might have been near steady state concentration, had plant production continued.

It is apparent that during the period 1/17-4/17, 1970, when the No. 1 aerator was out of service, that the increasing load from the industrial plant seemed to induce greater efficiency of overall removal of BOD_5, chlorophenols and chlorophenoxy acids by the aerated lagoon.

When the No. 1 aerator was returned to service, fractional removal of BOD_5 was not changed significantly. Some improvement noted in the fractional removal of chlorophenols and chlorophenoxy acids may have been due to reduction in their loading.

When the effect of the number of aerators in service is considered, it would appear that BOD_5 removal within the lagoon is somewhat improved by less stirring with an approximately constant BOD load. The average linear velocity within the lagoon is lowered as the pumping capacity decreases (fewer aerators operating). This would permit some settling of floc with consequent increase in mixed liquor settleable solids relative to biochemically oxidizable material. This behavior was subjectively confirmed by the observation that changing aerators when fewer than all four were running, always resulted in a temporary increase in settleable solids within the lagoon.

It is believed that oxidation within the lagoon could be improved by interposing a settling section from which active floc could be continuously returned and mixed with the influent flow to the lagoon.

Since the BOD5 of a waste is dependent among other factors on the nature of the waste and the bacterial population, a system subjected to a relatively constant high through-put volume should perform more efficiently if the flow is constantly fortified with acclimated bacterial floc.

It was observed that the BOD5 of the influent rose sharply immediately after a heavy rain. Infiltration apparently "scoured" the lines, bringing down a greater amount of oxidizable material and also a larger number of viable organisms. Continued heavy rain served to dilute both oxidizable waste and organisms, with consequent reduction in BOD_5.

SECTION XII

ACKNOWLEDGEMENTS

Mr. S. Ladd Davies, Director, Arkansas Pollution Control Commission, and members of the scientific and technical staff of the Commission, particularly Mr. Bobby G. Voss and Mr. James R. Shell, have been most cooperative and helpful since the inception of the grant proposal.

The design and construction phases of the project were under the able execution and supervision of Marion L. Crist & Associates, Inc., Little Rock, Arkansas. Mr. Marion L. Crist, Mr. Arnold J. Tyer, and Mr. Robert Yeatman of that organization are especially deserving of many thanks for their continued interest and assistance during the course of the project study.

Mr. Elmer H. Hines, Superintendent, Jacksonville Water & Sewer Department and Mr. Oscar Peeler, operator of the Jacksonville West Sewage Treatment Plant, deserve the lions share of credit for the actual operation of the combined treatment system.

Many thanks go also to Mr. Curtis Mahla and Mr. James T. French of the Design and Technical Section, Base Civil Engineers, Little Rock Air Force Base in appreciation of their advice during discussions and for aiding in provision of local climatological information.

It is with deepest gratitude that the assistance of Mr. James R. Shell and Mr. Neil Woomer, both of the Arkansas Pollution Control Commission, and of Dr. Clarence B. Sinclair, Chairman of the Department of Life Science, the University of Arkansas at Little Rock, is acknowledged in connection with the biological study.

Finally, it must be acknowledged that without the full cooperation of Mr. George C. Putnicki and other members of the staff of the Federal Water Quality Administration; Mr. John H. Harden, Mayor, and members of the Jacksonville City Council; the Officers and Directors of the Synthetics Department, Hercules Incorporated, Wilmington, Delaware, and the staff of the Arkansas Pollution Control Commission together with the hard, dedicated work of Mr. Israel C. Haidar, who performed most of the analytical tests and Mr. Bobby C. Brewer who performed most of the U V analyses, this report would not have been possible.

William Evans, M.S. Zoology

Albert E. Sidwell,PhD. Chem.

SECTION XIII

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APPENDIX A

SURVEY SUMMARY OF PLANKTON ORGANISMS

6/5/69 - 10/11/69

19 Samples

Scientific Name	Common Name	Average No./Liter
	Station 1	
Anabaena	blue-green alga	TNTC
Anacystis	blue-green alga	TNTC
Cladophora	green alga	105
Filinia	rotifer	105
Lecane	rotifer	52
Oscillatoria	blue-green alga	52
Pandorina	green flagellate	105
Phacus	protozoan	210
Synedra	diatom	578
Ulothrix	green alga	52
Volvox	green alga	52
Vorticella	ciliated protozoan	52
	Station 2	
Anabaena	blue-green alga	TNTC
Anacystis	blue-green alga	TNTC
Asplanchna	rotifer	52
Brachionus	rotifer	578
Chlorella	green alga	368
Chlorococcus	green alga	157
Cladophora	green alga	1,736
Coelosphaerium	blue-green alga	105
Cyclops	copepod	52
Filinia	rotifer	157
Gonium	green flagellate	421
Itura	rotifer	210
Lecane	rotifer	105
Lepadella	rotifer	1,368
Lyngbya	blue-green alga	52
Melosira	diatom	157
Monostyla	rotifer	105
Nematode	micro-round worm	52
Nostoc	blue-green alga	157
Oscillatoria	blue-green alga	1,736
Pandorina	green flagellate	315
Pediastrum	green alga	157
Phacus	protozoan	1,052
Philodina	rotifer	475

Scientific Name	Common Name	Average No./Liter
Platyias	rotifer	210
Pleodorina	green flagellate	368
Pleurotrocha	rotifer	210
Surirella	diatom	315
Synedra	diatom	1,157
Tardegrada	water bear	52
Ulothrix	green alga	105
Volvox	green alga	1,315
Voronkowia	rotifer	1,421
Vorticella	ciliated protozoan	789

Station 3

Anabaena	blue-green alga	TNTC
Anacystis	blue-green alga	TNTC
Asplanchna	rotifer	526
Bosmina	micro-crustacean	210
Brachionus	rotifer	1,473
Chlamydomonas	green flagellate	157
Chlorella	green alga	210
Chlorococcus	green alga	578
Ciliates	protozoans	526
Cladophora	green alga	947
Coelosphaerium	blue-green alga	52
Cyclops	copepod	210
Euglena	protozoan	526
Filinia	rotifer	210
Hexarthra	rotifer	736
Lecane	rotifer	105
Lepadella	rotifer	157
Lyngbya	blue-green alga	315
Melosira	diatom	57
Monostyla	rotifer	1,578
Oscillatoria	blue-green alga	2,368
Ostracoda	fairy shrimp	52
Pandorina	green flagellate	7,578
Phacus	protozoan	4,000
Pleodorina	green flagellate	263
Synedra	diatom	2,684
Ulothrix	green alga	105
Volvox	green alga	736
Voronkowia	rotifer	157
Vorticella	ciliated protozoan	157

Station 4

Anabaena	blue-green alga	170,930
Anacystis	blue-green alga	205,315

Scientific Name	Common Name	Average No./Liter
Asplanchna	rotifer	368
Brachionus	rotifer	736
Chlamydomonas	green flagellate	947
Chloroccus	green alga	6,842
Cladophora	green alga	1,368
Clostridium	green alga	52
Conochilus	rotifer	105
Euglena	protozoan	1,263
Filinia	rotifer	52
Gonium	green flagellate	263
Hexarthra	rotifer	210
Itura	rotifer	157
Lecane	rotifer	421
Lyngbya	blue-green alga	52
Monostyla	rotifer	842
Nostoc	blue-green alga	52
Oscillatoria	blue-green alga	3,263
Pandorina	green flagellate	3,000
Phacus	protozoan	3,630
Philodina	rotifer	684
Platydorina	green flagellate	52
Platyias	rotifer	1,000
Pleodorina	green flagellate	315
Synedra	diatom	4,421
Tetramastix	rotifer	105
Ulothrix	green alga	368
Volvox	green alga	526
Voronkowia	rotifer	52
Vorticella	ciliated protozoan	894

Station 5

Anabaena	blue-green alga	163,421
Anacystis	blue-green alga	184,894
Asplanchna	rotifer	526
Brachionus	rotifer	789
Chlamydomonas	green flagellate	368
Chlorella	green alga	684
Chlorococcus	green alga	6,157
Ciliates	protozoans	526
Cladophora	green alga	315
Conochilus	rotifer	157
Cyclops	copepod	210
Euglena	protozoan	1,526
Filinia	rotifer	473
Hexarthra	rotifer	315
Itura	rotifer	210
Lecane	rotifer	105

Scientific Name	Common Name	Average No./Liter
Lepadella	rotifer	263
Lyngbya	blue-green alga	210
Melosira	diatom	263
Monostyla	rotifer	842
Nostoc	blue-green alga	473
Oscillatoria	blue-green alga	4,000
Pandorina	green flagellate	2,421
Pediastrum	green alga	52
Phacus	protozoan	3,631
Philodina	rotifer	578
Platyias	rotifer	473
Pleurotrocha	rotifer	157
Surirella	diatom	52
Synedra	diatom	3,894
Tardegrada	water bear	105
Ulothrix	green alga	157
Volvox	green alga	1,052
Voronkowia	rotifer	52
Vorticella	ciliated protozoan	263
	Station 6	
Anabaena	blue-green alga	93,105
Anacystis	blue-green alga	101,052
Asplanchna	rotifer	315
Brachionus	rotifer	1,105
Chlamydomonas	green flagellate	842
Chlorococcus	green alga	3,210
Ciliates	protozoans	789
Cladophora	green alga	1,157
Conochilus	rotifer	157
Cyclops	copepod	105
Euglena	protozoan	210
Filinia	rotifer	894
Hexarthra	rotifer	421
Itura	rotifer	52
Keratella	rotifer	52
Lecane	rotifer	526
Lyngbya	blue-green alga	52
Melosira	diatom	52
Monostyla	rotifer	1,368
Nostoc	blue-green alga	263
Oscillatoria	blue-green alga	4,421
Pandorina	green flagellate	3,894
Phacus	protozoan	4,894
Philodina	rotifer	157
Phormidium	blue-green alga	105

Scientific Name	Common Name	Average No./Liter
Platyias	rotifer	473
Pleodorina	green flagellate	263
Synedra	diatom	1,526
Tetramastix	rotifer	157
Ulothrix	green alga	52
Volvox	green alga	1,052
Vorticella	ciliated protozoan	421

Station 7

Scientific Name	Common Name	Average No./Liter
Anabaena	blue-green alga	135,210
Anacystis	blue-green alga	155,263
Asplanchna	rotifer	1,210
Brachionus	rotifer	1,736
Chlamydomonas	green flagellate	684
Chlorella	green alga	578
Chlorococcus	green alga	5,210
Cladophora	green alga	1,578
Conochilus	rotifer	315
Cyclops	copepod	210
Cyclotella	diatom	315
Euglena	protozoan	789
Filinia	rotifer	526
Gonium	green flagellate	236
Itura	rotifer	157
Keratella	rotifer	157
Lecane	rotifer	263
Lepadella	rotifer	157
Lyngbya	blue-green alga	368
Monostyla	rotifer	789
Nematode	micro-round worm	52
Nostoc	blue-green alga	315
Oscillatoria	blue-green alga	4,105
Ostracoda	fairy shrimp	52
Pandorina	green flagellate	6,526
Phacus	protozoan	5,631
Philodina	rotifer	315
Platyias	rotifer	631
Pleurotrocha	rotifer	421
Synedra	diatom	5,052
Tabellaria	diatom	175
Tardegrada	water bear	52
Tetramastix	rotifer	157
Volvox	green alga	736
Vorticella	ciliated protozoan	894

Scientific Name	Common Name	Average No./Liter
	Station 8	
Anabaena	blue-green alga	112,315
Anacystis	blue-green alga	140,947
Ankistrodesmus	green alga	52
Asplanchna	rotifer	947
Brachionus	rotifer	1,263
Chlamydomonas	green flagellate	421
Chlorella	green alga	1,684
Chlorococcus	green alga	19,947
Ciliates	protozoans	315
Cladoceran parts	water fleas	473
Cladophora	green alga	1,736
Euglena	protozoan	1,421
Filinia	rotifer	578
Gonium	green flagellate	263
Hexarthra	rotifer	210
Itura	rotifer	315
Keratella	rotifer	52
Lecane	rotifer	105
Lepadella	rotifer	157
Lyngbya	blue-green alga	52
Melosira	diatom	105
Monostyla	rotifer	947
Navicula	diatom	52
Nematode	micro-round worm	52
Nostoc	blue-green alga	473
Oscillatoria	blue-green alga	5,894
Ostracoda	fairy shrimp	157
Pandorina	green flagellate	2,947
Phacus	protozoan	29,315
Platyias	rotifer	2,000
Pluerotrocha	rotifer	421
Synedra	diatom	4,000
Tardegrada	water bear	52
Ulothrix	green alga	105
Volvox	green alga	1,473
Voronkowia	rotifer	52
Vorticella	ciliated protozoan	736
	Station 9	
Anabaena	blue-green alga	104,473
Anacystis	blue-green alga	119,789
Asplanchna	rotifer	157
Bosmina	micro-crustacean	52
Brachionus	rotifer	894
Chlamydomonas	green flagellate	526

Scientific Name	Common Name	Average No./Liter
Chlorella	green alga	947
Chlorococcus	green alga	21,842
Cladoceran parts	water fleas	210
Cladophora	green alga	789
Conochilus	rotifer	52
Euglena	protozoan	1,105
Filinia	rotifer	421
Gonium	green flagellate	157
Hexarthra	rotifer	105
Keratella	rotifer	157
Lecane	rotifer	368
Lepadella	rotifer	105
Monostyla	rotifer	1,052
Navicula	diatom	368
Nostoc	blue-green alga	1,052
Ocystis	green alga	210
Oscillatoria	blue-green alga	3,789
Pandorina	green flagellate	1,368
Pediastrum	green alga	52
Phacus	protozoan	26,631
Philodina	rotifer	263
Platydorina	green flagellate	368
Platyias	rotifer	1,947
Synedra	diatom	3,105
Tetramastix	rotifer	263
Volvox	green alga	1,894
Vorticella	ciliated protozoan	263

Station 10

Anabaena	blue-green alga	165,789
Anacystis	blue-green alga	177,631
Asplanchna	rotifer	315
Brachionus	rotifer	473
Chlorella	green alga	1,421
Chlorococcus	green alga	28,947
Ciliates	protozoans	105
Cladoceran parts	water fleas	157
Cladophora	green alga	421
Cyclops	copepod	52
Euglena	protozoan	1,473
Filinia	rotifer	526
Gonium	green flagellate	421
Hexarthra	rotifer	105
Itura	rotifer	105
Lecane	rotifer	315
Lyngbya	blue-green alga	157
Melosira	diatom	105

Scientific Name	Common Name	Average No./Liter
Monostyla	rotifer	105
Navicula	diatom	315
Nostoc	blue-green alga	578
Ocystis	green alga	105
Oscillatoria	blue-green alga	2,631
Pandorina	green flagellate	2,421
Phacus	protozoan	24,578
Philodina	rotifer	263
Platyias	rotifer	1,473
Pleodorina	green flagellate	105
Synedra	diatom	3,736
Volvox	green alga	2,315
Vornokowia	rotifer	105
Vorticella	ciliated protozoan	473

Station 11

Anabaena	blue-green alga	141,315
Anacystis	blue-green alga	153,421
Asplanchna	rotifer	473
Brachionus	rotifer	1,947
Chlamydomonas	green flagellate	894
Chlorella	green alga	1,947
Chlorococcus	green alga	28,105
Cladoceran parts	water fleas	210
Cladophora	green alga	368
Cyclops	copepod	105
Euglena	protozoan	1,526
Filinia	rotifer	1,052
Gonium	green flagellate	526
Hexarthra	rotifer	157
Itura	rotifer	157
Keratella	rotifer	368
Lecane	rotifer	52
Lepadella	rotifer	105
Melosira	diatom	157
Monostyla	rotifer	1,105
Nostoc	blue-green alga	315
Oscillatoria	blue-green alga	3,526
Ostracoda	fairy shrimp	52
Pandorina	green flagellate	5,105
Phacus	protozoan	25,578
Philodina	rotifer	157
Platyias	rotifer	2,000
Pleodorina	green flagellate	52
Synedra	diatom	5,105
Tardegrada	water bear	52
Volvox	green alga	1,210

Scientific Name	Common Name	Average No./Liter
Vorticella	ciliated protozoan	105
	Station 12	
Anabaena	blue-green alga	125,210
Anacystis	blue-green alga	150,315
Brachionus	rotifer	894
Chlamydomonas	green flagellate	1,210
Chlorella	green alga	2,315
Chlorococcus	green alga	16,421
Ciliates	protozoans	789
Cladoceran parts	water fleas	263
Cladophora	green alga	736
Coelosphaerium	blue-green alga	52
Euglena	protozoan	1,105
Filinia	rotifer	368
Gonium	green flagellate	526
Hexarthra	rotifer	315
Lecane	rotifer	52
Lepadella	rotifer	105
Lyngbya	blue-green alga	157
Melosira	diatom	210
Monostyla	rotifer	315
Nostoc	blue-green alga	421
Oscillatoria	blue-green alga	3,368
Pandorina	green flagellate	2,789
Phacus	protozoan	26,631
Philodina	rotifer	368
Platyias	rotifer	2,210
Synedra	diatom	4,052
Tardegrada	water bear	52
Volvox	green alga	736
Voronkowia	rotifer	157
Vorticella	ciliated protozoan	473

SURVEY SUMMARY OF PLANKTON ORGANISMS

November 2, 9, 16, 23, 30, 1969

Scientific Name	Common Name	Average No./Liter
Station 1		
Anabaena	blue-green alga	12
Anacystis	blue-green alga	TNTC
Chlamydomonas	green flagellate	24
Cladophora	green alga	47
Filinia	rotifer	71
Hexarthra	rotifer	3
Lecane	rotifer	6
Oscillatoria	blue-green alga	3
Synedra	diatom	229
Ulothrix	green alga	569
Volvox	green alga	1
Station 2		
Anacystis	blue-green alga	TNTC
Asplanchna	rotifer	3
Brachionus	rotifer	66
Chlamydomonas	green flagellate	9
Chlorella (vulgaris)	green alga	127
Chlorococcus	green alga	2
Cladophora	green alga	79
Gonium	green flagellate	11
Itura	rotifer	76
Lepadella	rotifer	729
Melosira	diatom	191
Philodina	rotifer	15
Pleodorina	green flagellate	68
Surirella	diatom	27
Synedra	diatom	917
Ulothrix	green alga	2
Volvox	green alga	6,100
Voronkowia	rotifer	303
Vorticella	ciliated protozoan	16
Station 3		
Anabaena	blue-green alga	61
Anacystis	blue-green alga	1,425
Brachionus	rotifer	149
Chlorella (vulgaris)	green alga	870
Chlorococcus	green alga	1,331

Scientific Name	Common Name	Average No./Liter
Ciliates	protozoana	113
Cladophora	green alga	281
Euglena	protozoan	328
Hexarthra	rotifer	59
Monostyla	rotifer	178
Pandorina	green flagellate	1,302
Phacus	protozoan	189
Synedra	diatom	1,117
Ulothrix	green alga	142
Volvox	green alga	2,115
	Station 4	
Anabaena	blue-green alga	101
Anacystis	blue-green alga	9,831
Brachionus	rotifer	212
Chlorella (vulgaris)	green alga	856
Chlorococcus	green alga	1,297
Ciliates	protozoans	222
Cladophora	green alga	364
Euglena	protozoan	482
Hexarthra	rotifer	71
Monostyle	rotifer	269
Pandorina	green flagellate	1,515
Phacus	protozoan	191
Synedra	diatom	1,369
Ulothrix	green alga	166
Volvox	green alga	2,008
	Station 5	
Anabaena	blue-green alga	88
Anacystis	blue-green alga	1,012
Brachionus	rotifer	261
Chlorella (vulgaris)	green alga	743
Chlorococcus	green alga	1,421
Ciliates	protozoans	156
Cladophora	green alga	179
Conochilus	rotifer	10
Euglena	protozoan	340
Keratella	rotifer	5
Monostyla	rotifer	243
Pandorina	green flagellate	1,615
Phacus	protozoan	134
Synedra	diatom	1,212
Volvox	green alga	1,468

Scientific Name	Common Name	Average No./Liter
	Station 6	
Anabaena	blue-green alga	245
Anacystis	blue-green alga	1,119
Asplanchna	rotifer	2
Brachionus	rotifer	281
Chlorella (vulgaris)	green alga	546
Chlorococcus	green alga	1,407
Cladoceran parts	water fleas	1
Cladophora	green alga	91
Euglena	protozoan	134
Keratella	rotifer	33
Monostyla	rotifer	134
Pandorina	green flagellate	1,216
Phacus	protozoan	249
Synedra	diatom	896
Tetramastix	rotifer	3
Volvox	green alga	1,601
	Station 7	
Anabaena	blue-green alga	257
Anacystis	blue-green alga	1,804
Brachionus	rotifer	256
Chlorella (vulgaris)	green alga	619
Chlorococcus	green alga	909
Ciliates	protozoans	1
Cladophora	green alga	69
Euglena	protozoan	168
Keratella	rotifer	49
Monostyla	rotifer	127
Pandorina	green flagellate	669
Phacus	protozoan	397
Synedra	diatom	1,012
Volvox	green alga	1,963
	Station 8	
Anabaena	blue-green alga	19
Anacystis	blue-green alga	323
Brachionus	rotifer	701
Chlorella (vulgaris)	green alga	1,304
Chlorococcus	green alga	9,463
Cladophora	green alga	488
Euglena	protozoan	1,039
Filinia	rotifer	1,294
Gonium	green flagellate	29
Hexarthra	rotifer	360

Scientific Name	Common Name	Average No./Liter
Lecane	rotifer	211
Monostyla	rotifer	861
Oscillatoria	blue-green alga	2,909
Pendorina	green flagellate	1,016
Phacus	protozoan	9,473
Platyias	rotifer	179
Synedra	diatom	3,100
Volvox	green alga	1,043
Vorticella	ciliated protozoan	417

Station 9

Anabaena	blue-green alga	1
Anacystis	blue-green alga	412
Brachionus	rotifer	811
Chlorella (vulgaris)	green alga	913
Chlorococcus	green alga	8,900
Cladophora	green alga	396
Euglena	protozoan	999
Filinia	rotifer	906
Hexarthra	rotifer	293
Lecane	rotifer	187
Monostyla	rotifer	616
Oscillatoria	blue-green alga	911
Pandorina	green flagellate	763
Phacus	protozoan	5,494
Platyias	rotifer	44
Synedra	diatom	911
Ulothrix	green alga	836
Vorticella	ciliated protozoan	287

Station 10

Anacystis	blue-green alga	215
Brachionus	rotifer	696
Chlorella (vulgaris)	green alga	1,014
Chlorococcus	green alga	9,300
Cladophora	green alga	199
Euglena	protozoan	1,041
Filinia	rotifer	1,212
Hexarthra	rotifer	314
Lecane	rotifer	199
Monostyla	rotifer	608
Oscillatoria	blue-green alga	1,215
Pandorina	green flagellate	896
Phacus	protozoan	6,132
Platyias	rotifer	29
Synedra	diatom	1,096

Scientific Name	Common Name	Average No./Liter
Ulothrix	green alga	733
Vorticella	ciliated protozoan	331
	Station 11	
Anacystis	blue-green alga	311
Brachionus	rotifer	502
Chlorella (vulgaris)	green alga	997
Chlorococcus	green alga	9,901
Cladophora	green alga	259
Euglena	protozoan	1,414
Filinia	rotifer	1,639
Hexarthra	rotifer	414
Monostyla	rotifer	798
Oscillatoria	blue-green alga	1,624
Pandorina	green flagellate	966
Phacus	protozoan	7,342
Platyias	rotifer	36
Synedra	diatom	996
Ulothrix	green alga	604
Volvox	green alga	219
	Station 12	
Anacystis	blue-green alga	212
Brachionus	rotifer	319
Chlorella (vulgaris)	green alga	804
Chlorococcus	green alga	717
Cladophora	green alga	213
Euglena	protozoan	1,012
Filinia	rotifer	1,793
Hexarthra	rotifer	309
Monostyla	rotifer	688
Oscillatoria	blue-green alga	1,002
Pandorina	green flagellate	468
Phacus	protozoan	5,130
Platyias	rotifer	12
Synedra	diatom	866
Ulothrix	green alga	519
Volvox	green alga	98

SURVEY SUMMARY OF PLANKTON ORGANISMS

December 7, 14, 21, 28, 1969

Scientific Name	Common Name	Average No./Liter
	Station 1	
Anacystis	blue-green alga	TNTC
Chlamydomonas	green flagellate	18
Cladophora	green alga	44
Filinia	rotifer	70
Hexarthra	rotifer	4
Lecane	rotifer	6
Synedra	diatom	229
Ulothrix	green alga	495
Volvox	green alga	15
	Station 2	
Anacystis	blue-green alga	TNTC
Asplanchna	rotifer	2
Brachionus	rotifer	39
Chlamydomonas	green flagellate	12
Chlorella (vulgaris)	green alga	131
Chlorococcus	green alga	6
Cladophora	green alga	67
Cyclops	copepod	9
Gonium	green flagellate	15
Itura	rotifer	68
Lepadella	rotifer	616
Melosira	diatom	215
Nematode	micro-round worm	98
Ostracoda	fairy shrimp	1
Philodina	rotifer	12
Pleodorina	green flagellate	54
	Station 3	
Anacystis	blue-green alga	808
Brachionus	rotifer	135
Chlroella (vulgaris)	green alga	1,087
Chlorococcus	green alga	1,576
Ciliates	protozoans	82
Cladophora	green alga	672
Euglena	protozoan	478
Hexarthra	rotifer	76
Melosira	diatom	21
Monostyla	rotifer	84
Nematode	micro-round worm	1

Scientific Name	Common Name	Average No./Liter
Pandorina	green flagellate	1,460
PHacus	protozoan	186
Synedra	diatom	985
Ulothrix	green alga	123
Volvox	green alga	1,926
Vorticella	ciliated protozoan	93
	Station 4	
Anacystis	blue-green alga	560
Brachionus	rotifer	119
Chlorella (vulgaris)	green alga	1,166
Chlorococcus	green alga	1,697
Ciliates	protozoans	76
Cladophora	green alga	390
Euglena	protozoan	379
Hexarthra	rotifer	84
Monostyla	rotifer	41
Oscillatoria	blue-green alga	2
Pandorina	green flagellate	1,653
Phacus	protozoan	190
Phormidium	blue-green alga	15
Platyias	rotifer	3
Synedra	diatom	5,472
Ulothrix	green alga	110
Volvox	green alga	1,293
	Station 5	
Anabaena	blue-green alga	12
Anacystis	blue-green alga	621
Brachionus	rotifer	75
Chlorella (vulgaris)	green alga	1,019
Chlorococcus	green alga	1,314
Cladophora	green alga	196
Euglena	protozoan	324
Hexarthra	rotifer	16
Monostyla	rotifer	79
Pandorina	green flagellate	1,916
Phacus	protozoan	129
Phormidium	blue-green alga	47
Synedra	diatom	989
Volvox	green alga	1,212
	Station 6	
Anabaena	blue-green alga	17
Anacystis	blue-green alga	787
Brachionus	rotifer	88

Scientific Name	Common Name	Average No./Liter
Chlorella (vulgaris)	green alga	1,511
Chlorococcus	green alga	1,739
Cladophora	green alga	137
Euglena	protozoan	309
Monostyla	rotifer	160
Pandorina	green flagellate	1,089
Phacus	protozoan	297
Phormidium	blue-green alga	956
Synedra	diatom	864
Volvox	green alga	1,505
	Station 7	
Anabaena	blue-green alga	31
Anacystis	blue-green alga	864
Brachionus	rotifer	100
Chlorella (vulgaris)	green alga	1,620
Chlorococcus	green alga	1,588
Cladophora	green alga	153
Cyclops	copepod	1
Euglena	protozoan	333
Keratella	rotifer	6
Lyngbya	blue-green alga	2
Monostyla	rotifer	229
Pandorina	green flatellate	823
Phacus	protozoan	303
Phormidium	blue-green alga	414
Synedra	diatom	911
Volvox	green alga	1,739
	Station 8	
Anacystis	blue-green alga	611
Brachionus	rotifer	811
Chlorella (vulgaris)	green alga	1,519
Chlorococcus	green alga	9,190
Cladophora	green alga	516
Euglena	protozoan	1,240
Filinia	rotifer	993
Gonium	green flatellate	37
Hexarthra	rotifer	412
Lecane	rotifer	292
Monostyla	rotifer	901
Oscillatoria	blue-green alga	2,263
Pandorina	green flagellate	1,161
Phacus	protozoan	10,513
Platyias	rotifer	199

Scientific Name	Common Name	Average No./Liter
Synedra	diatom	4,556
Volvox	green alga	1,191
Vorticella	ciliated protozoan	608
	Station 9	
Anacystis	blue-green alga	402
Brachionus	rotifer	551
Chlorella (vulgaris)	green alga	1,003
Chlorococcus	green alga	6,010
Cladophora	green alga	212
Euglena	protozoan	913
Filinia	rotifer	496
Gonium	green flagellate	3
Hexarthra	rotifer	184
Lecane	rotifer	57
Monostyla	rotifer	499
Oscillatoria	blue-green alga	1,123
Pandorina	green flagellate	616
Phacus	protozoan	8,361
Platyias	rotifer	59
Synedra	diatom	2,413
Volvox	green alga	811
Vorticella	ciliated protozoan	315
	Station 10	
Anacystis	blue-green alga	415
Brachionus	rotifer	711
Chlorella (vulgaris)	green alga	1,176
Chlorococcus	green alga	7,112
Cladophora	green alga	319
Euglena	protozoan	1,019
Filinia	rotifer	459
Hexarthra	rotifer	20
Lecane	rotifer	3
Monostyla	rotifer	568
Oscillatoria	blue-green alga	1,202
Pandorina	green flagellate	723
Phacus	protozoan	8,181
Platyias	rotifer	84
Synedra	diatom	2,323
Volvox	green alga	987
Vorticella	ciliated protozoan	516

Scientific Name	Common Name	Average No./Liter
	Station 11	
Anacystis	blue-green alga	319
Brachionus	rotifer	844
Chlorella (vulgaris)	green alga	1,269
Chlroococcus	green alga	8,281
Cladophora	green alga	476
Euglena	protozoan	1,438
Filinia	rotifer	597
Hexarthra	rotifer	36
Monostyla	rotifer	694
Oscillatoria	blue-green alga	1,503
Pandorina	green flagellate	1,782
Phacus	protozoan	7,309
Platyias	rotifer	93
Synedra	diatom	2,982
Ulothrix	green alga	511
Volvox	green alga	991
Vorticella	ciliated protozoan	413
	Station 12	
Anacystis	blue-green alga	212
Brachionus	rotifer	648
Chlorella (vulgaris)	green alga	1,119
Chlorococcus	green alga	1,762
Cladoceran parts	water fleas	289
Filinia	rotifer	498
Hexarthra	rotifer	24
Monostyla	rotifer	505
Oscillatoria	blue-green alga	1,407
Pediastrum	green alga	1,822
Phacus	protozoan	6,903
Platyias	rotifer	87
Synedra	diatom	3,115
Ulothrix	green alga	409
Volvox	green alga	962
Vorticella	ciliated protozoan	212

SURVEY SUMMARY OF PLANKTON ORGANISMS

February 1, 8, 15, 22, 1970

Scientific Name	Common Name	Average No./Liter
	Station 1	
Anacystis	blue-green alga	TNTC
Chlamydomonas	green flagellate	27
Cladophora	green alga	43
Filinia	rotifer	69
Hexarthra	rotifer	6
Synedra	diatom	212
	Station 2	
Anacystis	blue-green alga	TNTC
Brachionus	rotifer	62
Cyclops	copepod	6
Cyclotella	diatom	1
Itura	rotifer	61
Lepadella	rotifer	590
Melosira	diatom	247
Surirella	diatom	15
Synedra	diatom	709
Voronkowia	rotifer	253
	Station 3	
Anacystis	blue-green alga	1,013
Asplanchna	rotifer	39
Brachionus	rotifer	103
Chlorella (vulgaris)	green alga	1,321
Chlorococcus	green alga	1,576
Ciliates	protozoans	81
Cladophora	green alga	462
Euglena	protozoan	322
Hexarthra	rotifer	81
Melosira	diatom	23
Monostyla	rotifer	93
Navicula	diatom	4
Pandorina	green flagellate	1,462
Phacus	protozoan	191
Synedra	diatom	983
Ulothrix	green alga	144
Vorticella	ciliated protozoan	63
	Station 4	

Scientific Name	Common Name	Average No./Liter
Anacystis	blue-green alga	747
Brachionus	rotifer	256
Chlorella (vulgaris)	green alga	860
Chlorococcus	green alga	1,213
Ciliates	protozoans	79
Cladophora	green alga	179
Coelosphaerium	blue-green alga	12
Euglena	protozoan	230
Filinia	rotifer	1
Hexarthra	rotifer	86
Keratella	rotifer	2
Monostyla	rotifer	81
Pandorina	green flagellate	1,670
Podiastrum	green alga	97
Synedra	diatom	1,590
Ulothrix	green alga	23

Station 5

Anacystis	blue-green alga	880
Brachionus	rotifer	89
Chlorella (vulgaris)	green alga	990
Chlorococcus	green alga	1,359
Ciliates	protozoans	143
Cladophora	green alga	182
Euglena	protozoan	241
Hexarthra	rotifer	12
Monostyla	rotifer	76
Pandorina	green flagellate	1,767
Synedra	diatom	1,309
Volvox	green alga	47

Station 6

Anacystis	blue-green alga	972
Asplanchna	rotifer	5
Brachionus	rotifer	129
Chlorella (vulgaris)	green alga	690
Chlorococcus	green alga	1,295
Ciliates	protozoans	136
Cladophora	green alga	12
Euglena	protozoan	207
Monostyla	rotifer	24
Pandorina	green flagellate	898
Synedra	diatom	903

Scientific Name	Common Name	Average No./Liter
	Station 7	
Anacystis	blue-green alga	724
Brachionus	rotifer	197
Chlorella (vulgaris)	green alga	823
Chlorococcus	green alga	1,026
Ciliates	protozoans	74
Cladophora	green alga	66
Euglena	protozoan	222
Monostyla	rotifer	89
Pandorina	green flagellate	667
Synedra	diatom	1,004
	Station 8	
Anacystis	blue-green alga	313
Asplanchna	rotifer	343
Brachionus	rotifer	407
Chlorella (vulgaris)	green alga	1,947
Chlorococcus	green alga	10,650
Cladophora	green alga	515
Euglena	protozoan	769
Filinia	rotifer	905
Gonium	green flagellate	37
Hexarthra	rotifer	404
Lecane	rotifer	305
Monostyla	rotifer	936
Oscillatoria	blue-green alga	319
Pandorina	green flagellate	909
Phacus	protozoan	8,120
Platyias	rotifer	200
Synedra	diatom	4,667
Volvox	green alga	932
Vorticella	ciliated protozoan	619
	Station 9	
Anacystis	blue-green alga	187
Asplanchna	rotifer	213
Brachionus	rotifer	222
Chlorella (vulgaris)	green alga	936
Chlorococcus	green alga	5,510
Cladophora	green alga	396
Euglena	protozoan	353
Filinia	rotifer	449
Gonium	green flagellate	12
Hexarthra	rotifer	311
Lecane	rotifer	96

Scientific Name	Common Name	Average No/Liter
Monostyla	rotifer	387
Oscillatoria	blue-green alga	97
Pandorina	green flagellate	415
Phacus	protozoan	3,995
Platyias	rotifer	59
Synedra	diatom	1,864
Volvox	green alga	405
Vorticella	ciliated protozoan	313
	Station 10	
Anacystis	blue-green alga	169
Asplanchna	rotifer	119
Brachionus	rotifer	121
Chlorella (vulgaris)	green alga	496
Chlorococcus	green alga	3,516
Cladophora	green alga	367
Euglena	protozoan	943
Filinia	rotifer	511
Hexarthra	rotifer	316
Lecane	rotifer	87
Monostyla	rotifer	219
Oscillatoria	blue-green alga	486
Pandorina	green flagellate	651
Phacus	protozoan	4,141
Platyias	rotifer	23
Synedra	diatom	2,209
Volvox	green alga	499
Vorticella	ciliated protozoan	412
	Station 11	
Anacystis	blue-green alga	56
Asplanchna	rotifer	27
Brachionus	rotifer	69
Chlorella (vulgaris)	green alga	161
Chlorococcus	green alga	2,151
Cladophora	green alga	276
Euglena	protozoan	804
Filinia	rotifer	324
Hexarthra	rotifer	211
Monostyla	rotifer	196
Oscillatoria	blue-green alga	269
Pandorina	green flagellate	591
Phacus	protozoan	5,101
Platyias	rotifer	12
Synedra	diatom	2,196
Volvox	green alga	328
Vorticella	ciliated protozoan	294

Scientific Name	Common Name	Average No./Liter
Station 12		
Anacystis	blue-green alga	44
Asplanchna	rotifer	12
Brachionus	rotifer	28
Chlorella (vulgaris)	green alga	76
Chlorococcus	green alga	1,915
Cladophora	green alga	269
Euglena	protozoan	706
Filinia	rotifer	229
Hexarthra	rotifer	107
Monostyla	rotifer	212
Oscillatoria	blue-green alga	278
Pandorina	green flagellate	463
Phacus	protozoan	4,009
Synedra	diatom	1,699
Volvox	green alga	228
Vorticella	ciliated protozoan	182

SURVEY SUMMARY OF PLANKTON ORGANISMS

March 1, 8, 15, 22, 1970

Scientific Name	Common Name	Average No./Liter
Station 1		
Anacystis	blue-green alga	TNTC
Chlamydomonas	green flagellate	15
Cladophora	green alga	39
Filinia	rotifer	71
Synedra	diatom	334
Ulothrix	green alga	126
Station 2		
Anabaena	blue-green alga	97
Anacystis	blue-green alga	TNTC
Asplanchna	rotifer	50
Chlorella (vulgaris)	green alga	12
Cladophora	green alga	89
Coelosphaerium	blue-green alga	126
Cyclotella	diatom	2
Itura	rotifer	72
Lepadella	rotifer	513
Nematode	Micro-round worm	101
Oscillatoria	blue-green alga	28
Pandorina	green flagellate	67
Pleodorina	green flagellate	59
Surirella	diatom	21
Synedra	diatom	808
Volvox	green alga	3,109
Station 3		
Anacystis	blue-green alga	896
Asplanchna	rotifer	3
Brachinous	rotifer	183
Chlorella (vulgaris)	green alga	1,155
Ciliates	protozoans	82
Cladophora	green alga	299
Euglena	protozoan	254
Hexarthra	rotifer	34
Keratella	rotifer	15
Monostyle	rotifer	96
Phacus	protozoan	215
Synedra	diatom	802
Ulothrix	green alga	101

Scientific Name	Common Name	Average No./Liter
Volvox	green alga	1,706
Vorticella	ciliated protozoan	59
	Station 4	
Anacystis	blue-green alga	666
Brachionus	rotifer	151
Chlorella (vulgaris)	green alga	609
Ciliates	protozoans	97
cladophora	green alga	156
Euglena	protozoan	217
Hexarthra	rotifer	39
Monostyle	rotifer	54
Phacus	protozoan	62
Synedra	diatom	6,003
Volvox	green alga	1,317
	Station 5	
Anacystis	blue-green alga	866
Chlorella (vulgaris)	green alga	1,006
Ciliates	protozoans	179
Cladophora	green alga	96
Euglena	protozoan	137
Monostyle	rotifer	43
Synedra	diatom	519
Tetramastix	rotifer	29
Volvox	green alga	987
	Station 6	
Anacystis	blue-green alga	689
Brachionus	rotifer	153
Chlorella (vulgaris)	green alga	919
Cladophora	green alga	79
Ciliates	protozoans	64
Euglena	protozoans	87
Filinia	rotifer	1
Hexarthra	rotifer	2
Monostyla	rotifer	134
Synedra	diatom	491
Ulothrix	green alga	1,059
	Station 7	
Anacystis	blue-green alga	799
Brachionus	rotifer	218

Scientific Name	Common Name	Average No./Liter
Chlorella (vulgaris)	green alga	761
Cladophora	green alga	124
Euglena	protozoan	50
Monostyla	rotifer	243
Synedra	diatom	619
Volvox	green alga	1,231

Station 8

Anacystis	blue-green alga	211
Ankistrodesmus	green alga	123
Asplanchna	rotifer	309
Brachionus	rotifer	283
Chlorella (vulgaris)	green alga	1,176
Chlorococcus	green alga	12,511
Cladophora	green alga	697
Euglena	protozoan	799
Filinia	rotifer	777
Gonium	green flagellate	136
Hexarthra	rotifer	144
Itura	rotifer	146
Keratella	rotifer	111
Monostyla	rotifer	694
Oscillatoria	blue-green alga	206
Pandorina	green flagellate	1,090
Phacus	protozoan	6,209
Platyias	rotifer	143
Synedra	diatom	3,565
Volvox	green alga	1,028
Vorticella	oiliated protozoan	444

Station 9

Anacystis	blue-green alga	173
Ankistrodesmus	green alga	10
Asplanchna	rotifer	215
Brachionus	rotifer	107
Chlorella (vulgaris)	green alga	930
Chlorococcus	green alga	844
Cladophora	green alga	213
Conochilus	rotifer	21
Euglena	protozoan	297
Filinia	rotifer	276
Genium	green flagellate	35
Hexatella	rotifer	87
Itura	rotifer	78

Scientific Name	Common Name	Average No./Liter
Lecane	rotifer	26
Monostyla	rotifer	399
Oscillatoria	blue-green alga	109
Pandorina	green flagellate	777
Phacus	protozoan	4,311
Platyias	rotifer	91
Synedra	diatom	1,090
Volvox	green alga	623
Vorticella	ciliated protozoan	199
	Station 10	
Anacystis	blue-green alga	116
Ankistrodesmus	green alga	113
Brachionus	rotifer	97
Chlorella (vulgaris)	green alga	980
Chlorococcus	green alga	766
Cladophora	green alga	319
Euglena	protozoan	276
Filinia	rotifer	191
Hexarthra	rotifer	23
Itura	rotifer	48
Monostyla	rotifer	425
Oscillatoria	blue-green alga	213
Pandorina	green flagellate	811
Phacus	protozoan	5,113
Platyias	rotifer	96
Synedra	diatom	1,209
Volvox	green alga	7,121
Vorticella	ciliated protozoan	314
	Station 11	
Anacystis	blue-green alga	94
Asplanchna	rotifer	83
Brachicnus	rotifer	49
Chlorella (vulgaris)	green alga	491
Chlorococcus	green alga	360
Cladophora	green alga	211
Euglena	protozoan	187
Filinia	rotifer	100
Hexarthra	rotifer	18
Itura	rotifer	51
Monostyla	rotifer	252
Oscillatoria	blue-green alga	103
Pandorina	green flagellate	819
Phacus	protozoan	4,211

Scientific Name	Common Name	Average No./Liter
Platyias	rotifer	86
Synedra	diatom	987
Volvox	green alga	409
Vorticella	ciliated protozoan	208

Station 12

Anacystis	blue-green alga	63
Asplanchna	rotifer	34
Brachionus	rotifer	26
Chlorella (vulgaris)	green alga	202
Chlorococcus	green alga	262
Cladophora	green alga	119
Euglena	protozoan	302
Filinia	rotifer	137
Hexarthra	rotifer	23
Itura	rotifer	31
Monostyla	rotifer	198
Oscillatoria	blue-green alga	94
Pandorina	green flagellate	486
Phacus	protozoan	3,490
Platyias	rotifer	44
Synedra	diatom	707
Volvox	green alga	323
Vorticella	ciliated protozoan	192

SURVEY SUMMARY OF PLANKTON ORGANISMS

May 3, 10, 17, 24, 1970

Scientific Name	Common Name	Average No./Liter
	Station 1	
Anabaena	blue-green alga	27
Anacystis	blue-green alga	TNTC
Chlamydomonas	green flagellate	16
Cladophora	green alga	41
Nostoc	blue-green alga	19
Oscillatoria	blue-green alga	13
Pleodorina	green flagellate	20
Synedra	diatom	307
Ulothrix	green alga	322
	Station 2	
Anabaena	blue-green alga	557
Anacystis	blue-green alga	TNTC
Asplanchna	rotifer	1
Brachionus	rotifer	62
Chlamydomonas	green flagellate	8
Chlorella (vulgaris)	green alga	78
Chlorococcus	green alga	3
Cladophora	green alga	33
Coelosphaerium	blue-green alga	411
Cyclops	copepod	4
Gonium	green flagellate	10
Itura	rotifer	36
Lepadella	rotifer	316
Melosira	diatom	200
Nematode	micro-round worm	91
Oscillatoria	blue-green alga	662
Pandorina	green flagellate	59
Pleodorina	green flagellate	44
Synedra	diatom	413
Volvox	green alga	3,346
Voronkowia	rotifer	27
	Station 3	
Anabaena	blue-green alga	661
Anacystis	blue-green alga	1,596
Asplanchna	rotifer	12
Bosmina	micro-crustacean	9
Brachionus	rotifer	54

Scientific Name	Common Name	Average No./Liter
Cladoceran parts	water fleas	31
Coelosphaerium	blue-green alga	5
Conochilus	rotifer	1
Hexarthra	rotifer	50
Lyngbya	blue-green alga	47
Monostyla	rotifer	68
Oscillatoria	blue-green alga	441
Phormidium	blue-green alga	342
Platyias	rotifer	3
Tetramastix	rotifer	13
	Station 4	
Anabaena	blue-green alga	1,061
Anacystis	blue-green alga	615
Brachionus	rotifer	259
Chlorella (vulgaris)	green alga	84
Cladoceran parts	water fleas	17
Coelosphaerium	blue-green alga	35
Hexarthra	rotifer	56
Lyngbya	blue-green alga	64
Monostyla	rotifer	72
Oscillatoria	blue-green alga	514
Phormidium	blue-green alga	512
	Station 5	
Anabaena	blue-green alga	981
Anacystis	blue-green alga	777
Brachionus	rotifer	77
Chlorella (vulgaris)	green alga	1,010
Conochilus	rotifer	3
Hexarthra	rotifer	34
Lyngbya	blue-green alga	187
Monostyla	rotifer	78
Oscillatoria	blue-green alga	1,096
Phormidium	blue-green alga	568
Synedra	diatom	5
Ulothrix	green alga	7
	Station 6	
Anabaena	blue-green alga	701
Anacystis	blue-green alga	819
Brachionus	rotifer	117
Chlorella (vulgaris)	green alga	919
Hexarthra	rotifer	7

Scientific Name	Common Name	Average No./Liter
Lyngbya	blue-green alga	201
Monostyla	rotifer	135
Oscillatoria	blue-green alga	1,291
Phormidium	blue-green alga	887
	Station 7	
Anabaena	blue-green alga	664
Anacystis	blue-green alga	907
Brachionus	rotifer	159
Chlorella (vulgaris)	green alga	1,012
Cyclops	copepod	1
Keratella	rotifer	3
Lyngbya	blue-green alga	236
Monostyla	rotifer	123
Oscillatoria	blue-green alga	1,611
Phormidium	blue-green alga	919
Synedra	diatom	3
	Station 8	
Anabaena	blue-green alga	20,690
Anacystis	blue-green alga	17,000
Ankistrodesmus	green alga	92
Asplanchna	rotifer	22
Brachionus	rotifer	44
Chlorella (vulgaris)	green alga	1,212
Chlorococcus	green alga	1,069
Cladophora	green alga	744
Euglena	protozoan	531
Filinia	rotifer	402
Gonium	green flagellate	319
Hexarthra	rotifer	10
Lecane	rotifer	14
Monostyla	rotifer	96
Ostillatoria	blue-green alga	1,094
Pandorina	green flagellate	737
Phacus	protozoan	19,937
Platyias	rotifer	23
Synedra	diatom	2,010
Ulothrix	green alga	745
Volvox	green alga	901
Vorticella	ciliated protozoan	56
	Station 9	
Anabaena	blue-green alga	26,972

Scientific Name	Common Name	Average No./Liter
Anacystis	blue-green alga	21,341
Ankistrodesmus	green alga	50
Asplanchna	rotifer	13
Brachionus	rotifer	21
Chlamydomonas	green flagellate	62
Chlorella (vulgaris)	green alga	804
Chlorococcus	green alga	1,111
Cladophora	green alga	881
Euglena	protozoan	616
Filinia	rotifer	211
Gonium	green flagellate	459
Monostyla	rotifer	66
Oscillatoria	blue-green alga	699
Pandorina	green flagellate	313
Phacus	protozoan	12,373
Platyias	rotifer	10
Synedra	diatom	1,818
Volvox	green alga	559
Vorticella	ciliated protozoan	68
	Station 10	
Anabaena	blue-green alga	30,869
Anacystis	blue-green alga	26,444
Asplanchna	rotifer	40
Brachionus	rotifer	29
Chlorella (vulgaris)	green alga	811
Chlorococcus	green alga	1,229
Cladophora	green alga	611
Euglena	protozoan	519
Filinia	rotifer	119
Monostyla	rotifer	168
Oscillatoria	blue-green alga	701
Pandorina	green flagellate	424
Phacus	protozoan	15,436
Platyias	rotifer	66
Synedra	diatom	2,323
Volvox	green alga	618
Vorticella	ciliated protozoan	62
	Station 11	
Anabaena	blue-green alga	37,968
Anacystis	blue-green alga	30,546
Asplanchna	rotifer	51
Brachionus	rotifer	19
Chlorella (vulgaris)	green alga	513
Chlorococcus	green alga	936

Scientific Name	Common Name	Average No./Liter
Cladophora	green alga	423
Euglena	protozoan	624
Filinia	rotifer	329
Monostyla	rotifer	179
Oscillatoria	blue-green alga	811
Pandorina	green flagellate	512
Phacus	protozoan	23,634
Platyias	rotifer	74
Synedra	diatom	2,515
Volvox	green alga	519
Vorticella	ciliated protozoan	26

Station 12

Anabaena	blue-green alga	43,936
Anacystis	blue-green alga	40,498
Asplanchna	rotifer	24
Brachionus	rotifer	10
Chlorella (vulgaris)	green alga	315
Chlorococcus	green alga	429
Cladophora	green alga	319
Euglena	protozoan	506
Filinia	rotifer	416
Monostyle	rotifer	101
Oscillatoria	blue-green alga	613
Pandorina	green flagellate	418
Phacus	protozoan	25,448
Platyias	rotifer	66
Synedra	diatom	2,444
Volvox	green alga	3,999
Vorticella	ciliated protozoan	11

APPENDIX B

Survey Summary - Fall, Winter, Spring and Summer Intensives

BACTERIOLOGICAL AND PHYSICAL DATA*

FALL INTENSIVE

TABLE B-1

October 18 through 31, 1969

Station Number	Water (°C) Temperature	pH	Dissolved Oxygen (ppm)	Avg. No. of Coliform Organisms/100 ml	
				Total	Fecal
No. 1	22	7.1	3.1	176,900	159,300
No. 2	18	7.9	7.6	83,117	70,009
No. 3	16	8.5	12.7	1,961	1,640
No. 4	15.3	8.4	12.9	1,590	1,467
No. 5	15.5	8.5	12.6	2,343	2,000
No. 6	15.7	8.6	12.8	2,807	2,322
No. 7	15.3	8.4	12.9	1,321	1,219
No. 8	15.5	8.9	13.1	1,677	1,299
No. 9	15.7	8.9	12.2	2,991	1,591
No. 10	15.5	8.7	12.7	3,000	1,898
No. 11	15.6	8.6	12.5	2,692	2,100
No. 12	15.4	8.8	12.7	2,555	2,112

*Average of 14 Samples.

TABLE B-2

PLANKTON ORGANISMS - FALL INTENSIVE

October 18 through 31, 1969

Scientific Name	Common Name	Average No./Liter
	Station No. 1	
Anabaena	blue-green alga	37
Anacystis	blue-green alga	TNTC
Chlamydomonas	green flgaellate	22
Cladophora	green alga	51
Filinia	rotifer	78
Hexarthra	rotifer	2
Lecane	rotifer	6
Oscillatoria	blue-green alga	19
Phormidium	blue-green alga	20
Synedra	diatom	222
Ulothrix	green alga	599
Volvox	green alga	5
	Station 2	
Anacystis	blue-green alga	TNTC
Brachionus	rotifer	69
Chlorella (vulgaris)	green alga	134
Ciliates	protozoans	2
Cladophora	green alga	81
Itura	rotifer	68
Lepadella	rotifer	761
Melosira	diatom	186
Phacus	protozoan	24
Pleodorina	green flagellate	72
Surirella	diatom	25
Synedra	diatom	975
Volvox	green alga	6,303
Voronkowia	rotifer	310
	Station 3	
Anabaena	blue-green alga	56
Anacystis	blue-green alga	1,399
Brachionus	rotifer	163
Chlorella (vulgaris)	green alga	913
Chlorococcus	green alga	1,297
Ciliates	protozoans	99
Cladophora	green alga	296

Scientific Name	Common Name	Average No./Liter
Euglena	protozoan	301
Hexarthra	rotifer	95
Monostyla	rotifer	152
Pandorina	green flagellate	1,252
Phacus	protozoan	198
Synedra	diatom	1,007
Ulothrix	green alga	167
Volvox	green alga	2,002
	Station 4	
Anabaena	blue-green alga	884
Anacystis	blue-green alga	431
Brachionus	rotifer	230
Chlorella (vulgaris)	green alga	890
Chlorococcus	green alga	1,010
Ciliates	protozoans	62
Cladophora	green alga	156
Euglena	protozoan	204
Hexarthra	rotifer	71
Monostyla	rotifer	83
Oscillatoria	blue-green alga	357
Pandorina	green flagellate	1,232
Phacus	protozoan	92
Synedra	diatom	7,021
Ulothrix	green alga	52
Volvox	green alga	1,005
	Station 5	
Anabaena	blue-green alga	133
Anacystis	blue-green alga	518
Brachionus	rotifer	113
Chlorella (vulgaris)	green alga	912
Chlorococcus	green alga	1,475
Ciliates	protozoans	96
Cladophora	green alga	184
Euglena	Protozoan	156
Hexarthra	rotifer	10
Monostyla	rotifer	293
Oscillatoria	blue-green alga	496
Pandorina	green flagellate	1,712
Phacus	protozoan	229
Synedra	diatom	1,515
Volvox	green alga	1,769

Scientific Name	Common Name	Average No./Liter
	Station 6	
Anabaena	blue-green alga	140
Anacystis	blue-green alga	672
Brachionus	rotifer	169
Chlorella (vulgaris)	green alga	821
Chlorococcus	green alga	1,054
Ciliates	protozoans	66
Cladophora	green alga	138
Euglena	protozoan	119
Monostyla	rotifer	139
Oscillatoria	blue-green alga	1,096
Pandorina	green flagellate	1,848
Pediastrum	green alga	5
Phacus	protozoan	293
Synedra	diatom	766
Volvox	green alga	1,296
	Station 7	
Anabaena	blue-green alga	166
Anacystis	blue-green alga	722
Brachionus	rotifer	255
Chlorella (vulgaris)	green alga	890
Chlorococcus	green alga	1,273
Ciliates	protozoans	46
Cladophora	green alga	120
Cyclops	copepod	1
Euglena	protozoan	229
Keratella	rotifer	6
Monostyla	rotifer	122
Oscillatoria	blue-green alga	1,313
Pandorina	green flagellate	787
Phacus	protozoan	301
Synedra	diatom	818
Volvox	green alga	1,314
	Station 8	
Anabaena	blue-green alga	143
Anacystis	blue-green alga	497
Asplanchna	rotifer	80
Brachionus	rotifer	361
Chlorella (vulgaris)	green alga	918
Chlorococcus	green alga	1,019
Ciliates	protozoans	83
Cladophora	green alga	154
Euglena	protozoan	313

Scientific Name	Common Name	Average No./Liter
Filinia	rotifer	27
Gonium	green flagellate	12
Hexarthra	rotifer	217
Lecane	rotifer	9
Lepadella	rotifer	13
Monostyla	rotifer	180
Oscillatoria	blue-green alga	1,227
Pandorina	green flagellate	762
Phacus	protozoan	422
Phormidium	blue-green alga	22
Platyias	rotifer	75
Synedra	diatom	1,226
Volvox	green alga	807
Vorticella	ciliated protozoan	19
	Station 9	
Anabaena	blue-green alga	159
Anacystis	blue-green alga	404
Asplanchna	rotifer	97
Brachionus	rotifer	443
Chlorella (vulgaris)	green alga	990
Chlorococcus	green alga	1,178
Cladophora	green alga	149
Euglena	protozoan	456
Filinia	rotifer	33
Gonium	green flagellate	17
Hexarthra	rotifer	156
Lecane	rotifer	28
Monostyla	rotifer	199
Oscillatoria	blue-green alga	1,576
Pandorina	green flagellate	877
Phacus	protozoan	573
Phormidium	blue-green alga	41
Platyias	rotifer	89
Synedra	diatom	1,363
Ulothrix	green alga	397
Volvox	green alga	991
Vorticella	ciliated protozoan	10
	Station 10	
Anabaena	blue-green alga	133
Anacystis	blue-green alga	501
Asplanchna	rotifer	129
Brachionus	rotifer	467
Chlorella (vulgaris)	green alga	496

Scientific Name	Common Name	Average No./Liter
Chlorococcus	green alga	1,199
Cladophora	green alga	263
Euglena	protozoan	688
Filinia	rotifer	49
Hexarthra	rotifer	188
Lecane	rotifer	9
Lepadella	rotifer	128
Monostyla	rotifer	233
Oscillatoria	blue-green alga	1,499
Pandorina	green flagellate	916
Phacus	protozoan	981
Phormidium	blue-green alga	68
Platyias	rotifer	156
Synedra	diatom	1,414
Volvox	green alga	1,050
Vorticella	ciliated protozoan	15

Station 11

Scientific Name	Common Name	Average No./Liter
Anabaena	blue-green alga	97
Anacystis	blue-green alga	211
Asplanchna	rotifer	163
Brachionus	rotifer	988
Chlorella (vulgaris)	green alga	596
Chlorococcus	green alga	13,119
Cladophora	green alga	465
Euglena	protozoan	789
Filinia	rotifer	499
Hexarthra	rotifer	268
Monostyla	rotifer	415
Oscillatoria	blue-green alga	2,398
Pandorina	green flagellate	911
Phacus	protozoan	1,019
Phormidium	blue-green alga	78
Platyias	rotifer	189
Synedra	diatom	1,672
Ulothrix	green alga	493
Volvox	green alga	1,151

Station 12

Scientific Name	Common Name	Average No./Liter
Anabaena	blue-green alga	126
Anacystis	blue-green alga	252
Asplanchna	rotifer	197
Brachionus	rotifer	968
Chlorella (vulgaris)	green alga	436

Scientific Name	Common Name	Average No./Liter
Chlorococcus	green alga	10,337
Ciliates	protozoans	13
Cladophora	green alga	547
Euglena	protozoan	878
Filinia	rotifer	509
Hexarthra	rotifer	198
Monostyla	rotifer	502
Oscillatoria	blue-green alga	40,019
Pandorina	green flagellate	816
Phacus	protozoan	22,111
Phormidium	blue-green alga	86
Platyias	rotifer	293
Synedra	diatom	1,918
Ulothrix	green alga	511
Volvox	green alga	1,015

BACTERIOLOGICAL AND PHYSICAL DATA*

WINTER INTENSIVE
TABLE B-3
January 4 through 17, 1970

Station Number	Water (°C) Temperature	pH	Dissolved Oxygen (ppm)	Avg. No. of Coliform Organisms/100 ml	
				Total	Fecal
No. 1	13.9	4.8	5.5	153,212	121,111
No. 2	12.0	6.9	6.7	79,226	78,113
No. 3	13.1	8.1	9.3	3,493	3,005
No. 4	13.0	7.9	9.3	2,997	2,600
No. 5	13.0	7.8	9.5	3,222	2,801
No. 6	13.2	7.7	9.5	3,005	2,504
No. 7	13.1	8.0	9.6	2,001	1,559
No. 8	13.1	8.0	9.9	2,509	2,116
No. 9	13.2	8.1	9.4	3,233	2,881
No. 10	13.1	8.2	9.5	2,569	1,991
No. 11	13.0	7.9	9.1	2,655	1,459
No. 12	13.1	8.1	9.0	2,489#	1,696#

*Average of 14 Samples
#Average of 13 Samples

TABLE B-4

PLANKTON ORGANISMS - WINTER INTENSIVE

January 4 through 17, 1970

Scientific Name	Common Name	Average No./Liter
Station 1		
Anacystis	blue-green alga	TNTC
Chlamydomonas	green flagellate	16
Cladophora	green alga	46
Filinia	rotifer	78
Hexarthra	rotifer	18
Synedra	diatom	448
Station 2		
Anacystis	blue-green alga	TNTC
Brachionus	rotifer	50
Chlorella (vulgaris)	green alga	63
Cyclops	copeped	4
Cyclotella	diatom	2
Itura	rotifer	54
Lepadella	rotifer	495
Melosira	diatom	205
Nematode	micro-round worm	97
Philodina	rotifer	9
Surirella	diatom	9
Synedra	diatom	682
Station 3		
Anacystis	blue-green alga	997
Brachionus	rotifer	119
Chlorella (vulgaris)	green alga	1,199
Chlorococcus	green alga	1,601
Ciliates	protozoans	93
Cladophora	green alga	401
Cyclops	copeped	6
Euglena	protozoan	313
Hexarthra	rotifer	88
Melosira	diatom	27
Monostyla	rotifer	109
Pandorina	green flagellate	1,319
Phacus	protozoan	202
Platyias	rotifer	7
Synedra	diatom	1,016

Scientific Name	Common Name	Average No./Liter
Ulothrix	green alga	134
Volvox	green alga	1,873
	Station 4	
Anacystis	blue-green alga	575
Brachionus	rotifer	230
Chlorella (vulgaris)	green alga	1,016
Ciliates	protozoans	99
Cladophora	green alga	742
Euglena	protozoan	209
Hexarthra	rotifer	56
Monostyla	rotifer	19
Pandorina	green flagellate	1,597
Phacus	protozoan	95
Platyias	rotifer	13
Synedra	diatom	1,290
Ulothrix	green alga	126
Volvox	green alga	1,335
	Station 5	
Anacystis	blue-green alga	711
Brachionus	rotifer	123
Chlorella (vulgaris)	green alga	1,010
Ciliates	protozoans	143
Cladophora	green alga	242
Conochilus	rotifer	1
Euglena	protozoan	174
Monostyla	rotifer	12
Pandorina	green flagellate	1,379
Phacus	protozoan	5
Synedra	diatom	1,478
Ulothrix	green alga	29
Volvox	green alga	984
	Station 6	
Anacystis	blue-green alga	832
Brachionus	rotifer	176
Chlorella (vulgaris)	green alga	834
Ciliates	protozoans	165
Cladophora	green alga	129
Euglena	protozoan	99
Hexarthra	rotifer	3
Keratella	rotifer	6

Scientific Name	Common Name	Average No./Liter
Monostyla	rotifer	33
Pandorina	green flagellate	810
Synedra	diatom	906
Volvox	green alga	1,018
	Station 7	
Anacystis	blue-green alga	913
Brachionus	rotifer	263
Chlorella (vulgaris)	green alga	900
Ciliates	protozoans	76
Cladophora	green alga	140
Euglena	protozoan	101
Monostyla	rotifer	12
Pandorina	green flagellate	713
Synedra	diatom	1,023
Volvox	green alga	799
	Station 8	
Anabaena	blue-green alga	519
Asplanchna	rotifer	797
Brachionus	rotifer	933
Chlorella (vulgaris)	green alga	1,823
Chlorococcus	green alga	9,965
Cladophora	green alga	703
Euglena	protozoan	1,408
Filinia	rotifer	1,055
Gonium	green flagellate	43
Hexarthra	rotifer	521
Lecane	rotifer	327
Monostyla	rotifer	1,090
Oscillatoria	blue-green alga	437
Pandorina	green flagellate	1,216
Phacus	protozoan	9,316
Platyias	rotifer	205
Synedra	diatom	5,640
Volvox	green alga	1,009
Vorticella	ciliated protozoan	771
	Station 9	
Anacystis	blue-green alga	303
Asplanchna	rotifer	478
Brachionus	rotifer	439
Chlorella (vulgaris)	green alga	1,132
Chlorococcus	green alga	4,343

Scientific Name	Common Name	Average No./Liter
Cladophora	green alga	350
Euglena	protozoan	819
Filinia	rotifer	812
Gonium	green flagellate	12
Hexarthra	rotifer	119
Lecane	rotifer	94
Monostyla	rotifer	708
Oscillatoria	blue-green alga	175
Pandorina	green flagellate	817
Phacus	protozoan	4,410
Platyias	rotifer	199
Synedra	diatom	2,234
Volvox	green alga	719
Vorticella	ciliated protozoan	344
	Station 10	
Anacystis	blue-green alga	259
Asplanchna	rotifer	406
Brachionus	rotifer	491
Chlorella (vulgaris)	green alga	913
Chlorococcus	green alga	4,619
Cladophora	green alga	366
Euglena	protozoan	911
Filinia	rotifer	919
Hexarthra	rotifer	97
Lecane	rotifer	126
Monostyla	rotifer	538
Oscillatoria	blue-green alga	98
Pandorina	green flagellate	292
Phacus	protozoan	3,916
Platyias	rotifer	227
Synedra	diatom	3,001
Volvox	green alga	514
Vorticella	ciliated protozoan	76
	Station 11	
Anacystis	blue-green alga	225
Asplanchna	rotifer	411
Brachionus	rotifer	563
Chlorella (vulgaris)	green alga	1,015
Chlorococcus	green alga	612
Cladophora	green alga	469
Euglena	protozoan	1,121
Filinia	rotifer	908
Hexarthra	rotifer	132

Scientific Name	Common Name	Average No./Liter
Monostyla	rotifer	719
Oscillatoria	blue-green alga	68
Pandorina	green flagellate	283
Phacus	protozoan	3,872
Platyias	rotifer	419
Synedra	diatom	2,938
Ulothrix	green alga	211
Volvox	green alga	422
Vorticella	ciliated protozoan	64
	Station 12	
Anacystis	blue-green alga	210
Asplanchna	rotifer	314
Brachionus	rotifer	416
Chlorella (vulgaris)	green alga	985
Chlorococcus	green alga	715
Cladophora	green alga	511
Euglena	protozoan	1,301
Filinia	rotifer	1,015
Hexarthra	rotifer	222
Monostyla	rotifer	505
Oscillatoria	blue-green alga	52
Pandorina	green flagellate	198
Phacus	protozoan	2,987
Platyias	rotifer	311
Synedra	diatom	2,123
Ulothrix	green alga	190
Volvox	green alga	222
Vorticella	ciliated protozoan	98

BACTERIOLOGICAL AND PHYSICAL DATA*

SPRING INTENSIVE

TABLE B-5

March 29 through April 11, 1970

Station Number	Water (°C) Temperature	pH	Dissolved Oxygen (ppm)	Avg. No. of Coliform Organisms/100 ml	
				Total	Fecal
No. 1	17.6	6.4	6.1	197,367	160,501
No. 2	17.1	7.3	7.3	160,112	112,199
No. 3	17.9	7.8	9.7	2,433	2,100
No. 4	18.0	7.6	9.8	2,867	2,222
No. 5	17.8	7.9	9.8	2,929	2,113
No. 6	17.9	7.7	9.0	2,006	1,615
No. 7	17.8	7.7	9.9	2,123	1.877
No. 8	17.9	8.1	9.6	2,779#	1,781#
No. 9	17.9	8.0	9.7	2,722	2,451
No. 10	18.0	7.9	9.6	3,512	3,127
No. 11	17.9	7.9	9.9	2,916	2,079
No. 12	17.9	8.1	10.1	2,873	2,555

*Average of 14 Samples

#Average of 13 Samples

TABLE B-6

PLANKTON ORGANISMS - SPRING INTENSIVE

March 29 through April 11, 1970

Scientific Name	Common Name	Average No./Liter
	Station 1	
Anacystis	blue-green alga	TNTC
Chlamydomonas	green flagellate	16
Cladophora	green alga	41
Filinia	rotifer	77
Synedra	diatom	501
Ulothrix	green alga	468
	Station 2	
Anabaena	blue-green alga	112
Anacystis	blue-green alga	TNTC
Asplanchna	rotifer	2
Brachionus	rotifer	62
Chlorella (vulgaris)	green alga	9
Cladophora	green alga	71
Coelosphaerium	blue-green alga	152
Itura	rotifer	99
Lepadella	rotifer	612
Nematode	micro-round worm	129
Nostoc	blue-green alga	53
Pleodorina	green flagellate	72
Synedra	diatom	613
Volvox	green alga	4,401
	Station 3	
Anacystis	blue-green alga	992
Brachionus	rotifer	197
Chlorella (vulgaris)	green alga	1,339
Chlorococcus	green alga	910
Ciliates	protozoans	93
Cladophora	green alga	401
Dipteran Larvae	midge	1
Euglena	protozoan	333
Melosira	diatom	10
Navicula	diatom	5
Pandorina	green flagellate	1,414
Phacus	protozoan	251
Synedra	diatom	1,002
Ulothrix	green alga	143
Volvox	green alga	1,830

Scientific Name	Common Name	Average No./Liter
Vorticella	ciliated protozoan	69
Station 4		
Anacystis	blue-green alga	699
Brachionus	rotifer	178
Chlorella (vulgaris)	green alga	800
Chlorococcus	green alga	1,069
Ciliates	protozoans	78
Cladophora	green alga	139
Euglena	protozoan	216
Pandorina	green flagellate	620
Phacus	protozoan	88
Synedra	diatom	2,200
Ulothrix	green alga	139
Volvox	green alga	1,051
Vorticella	ciliated protozoan	36
Station 5		
Anacystis	blue-green alga	899
Asplanchna	rotifer	3
Brachionus	rotifer	921
Chlorella (vulgaris)	green alga	991
Chlorococcus	green alga	1,603
Ciliates	protozoans	159
Cladophora	green alga	151
Euglena	protozoan	144
Hexarthra	rotifer	1
Keratella	rotifer	4
Pandorina	green flagellate	982
Phacus	protozoan	222
Platyias	rotifer	3
Synedra	diatom	820
Volvox	green alga	1,512
Station 6		
Anacystis	blue-green alga	1,098
Brachionus	rotifer	178
Chlorella (vulgaris)	green alga	855
Chlorococcus	green alga	1,653
Ciliates	protozoans	168
Cladophora	green alga	112
Euglena	protozoan	96
Filinia	rotifer	1
Hexarthra	rotifer	4
Keratella	rotifer	15

Scientific Name	Common Name	Average No./Liter
Lepadella	rotifer	1
Pandorina	green flagellate	1,002
Phacus	protozoan	422
Volvox	green alga	1,212
	Station 7	
Anacystis	blue-green alga	1,801
Brachionus	rotifer	212
Chlorella (vulgaris)	green alga	888
Chlorococcus	green alga	1,438
Ciliates	protozoans	147
Cladophora	green alga	76
Euglena	protozoan	180
Keratella	rotifer	29
Pandorina	green flagellate	801
Phacus	protozoan	512
Ulothrix	green alga	722
	Station 8	
Anacystis	blue-green alga	235
Ankistrodesmus	green alga	274
Asplanchna	rotifer	119
Brachionus	rotifer	198
Chlamydomonas	green flagellate	413
Chlorella (vulgaris)	green alga	1,296
Chlorococcus	green alga	12,967
Cladophora	green alga	896
Euglena	protozoan	613
Filinia	rotifer	571
Gonium	green flagellate	461
Hexarthra	rotifer	59
Lecane	rotifer	88
Monostyla	rotifer	387
Oscillatoria	blue-green alga	153
Pandorina	green flagellate	1,219
Phacus	protozoan	4,370
Platyias	rotifer	56
Synedra	diatom	3,333
Ulothrix	green alga	912
Volvox	green alga	1,556
Vorticella	ciliated protozoan	211
	Station 9	
Anacystis	blue-green alga	113

Scientific Name	Common Name	Average No./Liter
Asplanchna	rotifer	74
Brachionus	rotifer	69
Chlorella (vulgaris)	green alga	872
Chlorococcus	green alga	6,678
Cladophora	green alga	397
Euglena	protozoan	232
Filinia	rotifer	456
Gonium	green flagellate	198
Hexarthra	rotifer	13
Lecane	rotifer	23
Monostyla	rotifer	390
Oscillatoria	blue-green alga	76
Pandorina	green flagellate	813
Phacus	protozoan	4,409
Platyias	rotifer	27
Synedra	diatom	2,002
Volvox	green alga	1,600
Vorticella	ciliated protozoan	103

Station 10

Anacystis	blue-green alga	92
Asplanchna	rotifer	62
Brachionus	rotifer	54
Chlorella (vulgaris)	green alga	729
Chlorococcus	green alga	7,701
Cladophora	green alga	463
Euglena	protozoan	359
Filinia	rotifer	664
Hexarthra	rotifer	29
Lecane	rotifer	44
Monostyla	rotifer	511
Oscillatoria	blue-green alga	294
Pandorina	green flagellate	918
Phacus	protozoan	5,656
Platyias	rotifer	197
Synedra	diatom	2,916
Volvox	green alga	2,611
Vorticella	ciliated protozoan	54

Station 11

Anacystis	blue-green alga	66
Asplanchna	rotifer	12
Brachionus	rotifer	32
Chlorella (vulgaris)	green alga	418

Scientific Name	Common Name	Average No./Liter
Chlorococcus	green alga	8,879
Cladophora	green alga	623
Euglena	protozoan	493
Filinia	rotifer	446
Hexarthra	rotifer	22
Monostyla	rotifer	413
Oscillatoria	blue-green alga	299
Phacus	protozoan	5,133
Platydorina	green flagellate	816
Platyias	rotifer	102
Synedra	diatom	28
Volvox	green alga	2,715
Vorticella	ciliated protozoan	29

Station 12

Scientific Name	Common Name	Average No./Liter
Anacystis	blue-green alga	78
Asplanchna	rotifer	9
Brachionus	rotifer	12
Chlorella (vulgaris)	green alga	212
Chlorococcus	green alga	4,648
Cladophora	green alga	319
Euglena	protozoan	348
Filinia	rotifer	267
Hexarthra	rotifer	13
Monostyla	rotifer	323
Oscillatoria	blue-green alga	360
Phacus	protozoan	5,234
Phormidium	blue-green alga	702
Platyias	rotifer	93
Synedra	diatom	15
Volvox	green alga	2,219

BACTERIOLOGICAL AND PHYSICAL DATA*

SUMMER INTENSIVE

TABLE B-7

June 16 through 29, 1970

Station Number	Water (°C) Temperature	pH	Dissolved Oxygen (ppm)	Avg. No. of Coliform Organisms/100 ml	
				Total	Fecal
No. 1	25.5	7.1	3.0	240,401	179,600
No. 2	25.0	7.6	6.4	167,077	113,227
No. 3	26.9	8.4	13.9	4,476	3,511
No. 4	27.3	8.8	13.8	4,929	3,909
No. 5	27.4	8.5	13.7	5,251	3,876
No. 6	27.8	8.6	14.2	4,983	3,400
No. 7	27.5	8.5	14.1	4,501	3,107
No. 8	27.5	8.7	12.1	5,115	3,623
No. 9	27.2	8.8	12.4	4,906	3,444
No. 10	27.6	8.9	12.6	5,507	4,019
No. 11	27.8	8.5	13.3	5,262	3,721
No. 12	27.5	8.7	13.6	5,188	4,591

*Average of 14 Samples

TABLE B-8

PLANKTON ORGANISMS - SUMMER INTENSIVE

June 16 through 29, 1970

Scientific Name	Common Name	Average No./Liter
Station 1		
Anabaena	blue-green alga	173
Anacystis	blue-green alga	TNTC
Chlamydomonas	green flagellate	9
Cladophora	green alga	13
Filinia	rotifer	23
Hexarthra	rotifer	1
Lecane	rotifer	5
Nostoc	blue-green alga	49
Oscillatoria	blue-green alga	66
Phormidium	blue-green alga	77
Synedra	diatom	507
Ulothrix	green alga	226
Station 2		
Anabaena	blue-green alga	1,593
Anacystis	blue-green alga	TNTC
Chlamydomonas	green flagellate	9
Coelosphaerium	blue-green alga	586
Gonium	green flagellate	27
Nostoc	blue-green alga	29
Oscillatoria	blue-green alga	787
Pandorina	green flagellate	153
Pleodorina	green flagellate	66
Vorticella	ciliated protozoan	27
Station 3		
Anabaena	blue-green alga	816
Anacystis	blue-green alga	1,701
Asplanchna	rotifer	22
Brachionus	rotifer	73
Coelosphaerium	blue-green alga	12
Conochilus	rotifer	2
Hexarthra	rotifer	79
Lyngbya	blue-green alga	60
Monostyla	rotifer	17
Oscillatoria	blue-green alga	573
Pandorina	green flagellate	1,112
Platyias	rotifer	13
Tetramastix	rotifer	24

Scientific Name	Common Name	Average No./Liter
Volvox	green alga	1
	Station 4	
Anabaena	blue-green alga	1,010
Anacystis	blue-green alga	626
Brachionus	rotifer	230
Chlorella (vulgaris)	green alga	10
Coelosphaerium	blue-green alga	43
Hexarthra	rotifer	63
Lyngbya	blue-green alga	74
Monostyla	rotifer	101
Oscillatoria	blue-green alga	737
Pandorina	green flagellate	1,442
Synedra	diatom	50
Tetramastix	rotifer	17
Ulothrix	green alga	19
	Station 5	
Anabaena	blue-green alga	1,310
Anacystis	blue-green alga	718
Brachionus	rotifer	112
Chlorella (vulgaris)	green alga	909
Hexarthra	rotifer	43
Lyngbya	blue-green alga	174
Monostyla	rotifer	96
Oscillatoria	blue-green alga	1,073
Pandorina	green flagellate	1,814
Synedra	diatom	925
	Station 6	
Anabaena	blue-green alga	1,512
Anacystis	blue-green alga	913
Brachionus	rotifer	126
Chlorella (vulgaris)	green alga	1,005
Cladoceran parts	water fleas	2
Hexarthra	rotifer	36
Lyngbya	blue-green alga	212
Monostyla	rotifer	137
Oscillatoria	blue-green alga	1,111
Pandorina	green flagellate	989
Synedra	diatom	816

Scientific Name	Common Name	Average No./Liter
Station 7		
Anabaena	blue-green alga	2,100
Anacystis	blue-green alga	1,025
Brachionus	rotifer	206
Chlorella (vulgaris)	green alga	1,150
Cyclops	copepod	1
Lyngbya	blue-green alga	266
Monostyla	rotifer	159
Oscillatoria	blue-green alga	1,502
Pandorina	green flagellate	1,010
Synedra	diatom	953
Station 8		
Anabaena	blue-green alga	235,111
Anacystis	blue-green alga	222,110
Ankistrodesmus	green alga	50
Asplanchna	rotifer	10
Brachionus	rotifer	39
Chlorella (vulgaris)	green alga	411
Chlorococcus	green alga	321
Cladophora	green alga	237
Coelosphaerium	blue-green alga	101
Euglena	protozoan	353
Filinia	rotifer	102
Gonium	green flagellate	111
Monostyla	rotifer	12
Nostoc	blue-green alga	813
Oscillatoria	blue-green alga	3,596
Pandorina	green flagellate	638
Phacus	protozoan	38,904
Platyias	rotifer	1
Synedra	diatom	992
Volvox	green alga	311
Vorticella	ciliated protozoan	26
Station 9		
Anabaena	blue-green alga	343,432
Anacystis	blue-green alga	291,502
Ankistrodesmus	green alga	36
Asplanchna	rotifer	1
Brachionus	rotifer	22
Chlorella (vulgaris)	green alga	191
Chlorococcus	green alga	166
Cladophora	green alga	103

Scientific Name	Common Name	Average No./Liter
Coelosphaerium	blue-green alga	76
Euglena	protozoan	415
Filinia	rotifer	99
Gonium	green flagellate	151
Monostyla	rotifer	22
Nostoc	blue-green alga	537
Oscillatoria	blue-green alga	4,679
Pandorina	green flagellate	746
Phacus	protozoan	43,837
Synedra	diatom	877
Volvox	green alga	221
Vorticella	ciliated protozoan	5
	Station 10	
Anabaena	blue-green alga	356,513
Anacystis	blue-green alga	312,429
Brachionus	rotifer	27
Chlorella (vulgaris)	green alga	211
Chlorococcus	green alga	199
Cladophora	green alga	191
Cyclops	copepod	9
Cyclotella	diatom	11
Euglena	protozoan	612
Filinia	rotifer	213
Gonium	green flagellate	101
Monostyla	rotifer	34
Nostoc	blue-green alga	473
Oscillatoria	blue-green alga	10,769
Pandorina	green flagellate	649
Phacus	protozoan	44,900
Synedra	diatom	989
Volvox	green alga	311
	Station 11	
Anabaena	blue-green alga	375,613
Anacystis	blue-green alga	340,356
Brachionus	rotifer	22
Chlorella (vulgaris)	green alga	109
Chlorococcus	green alga	190
Cladophora	green alga	101
Euglena	protozoan	413
Filinia	rotifer	210
Monostyla	rotifer	29
Nostoc	blue-green alga	232
Oscillatoria	blue-green alga	23,847

Scientific Name	Common Name	Average No./Liter
Pandorina	green flagellate	468
Phacus	protozoan	45,300
Synedra	diatom	894
Volvox	green alga	212
	Station 12	
Anabaena	blue-green alga	401,312
Anacystis	blue-green alga	376,605
Brachionus	rotifer	12
Chlorella (vulgaris)	green alga	98
Chlorococcus	green alga	89
Cladophora	green alga	64
Cyclops	copepod	12
Euglena	protozoan	293
Filinia	rotifer	186
Monostyla	rotifer	44
Nostoc	blue-green alga	395
Oscillatoria	blue-green alga	21,936
Pandorina	green flagellate	239
Phacus	protozoan	34,900
Synedra	diatom	986
Volvox	green alga	194

SURVEY SUMMARY OF BACTERIOLOGOCAL DATA

COLIFORM ORGANISMS/100 ML*

TABLE B-9

June 5 through Oct. 11,1969

Station Number	Maximum		Minimum		Average	
	Total	Fecal	Total	Fecal	Total	Fecal
No. 1	253,000	198,000	126,000	85,000	183,473	130,815
No. 2	176,000	91,000	62,000	46,500	90,092	68,281
No. 3	5,000	9,500	2,100	1,750	3,595	3,066
No. 4	4,950	4,425	1,100	600	3,458	2,867
No. 5	5,050	4,000	2,000	1,452	3,646	3,432
No. 6	5,200	4,200	2,050	1,312	3,605	2,969
No. 7	4,985	4,200	2,105	1,516	3,487	2,833
No. 8	5,600	4,100	1,200	1,050	3,711	2,815
No. 9	5,500	4,005	2,075	1,385	3,632	2,790
No. 10	6,125	4,000	2,340	1,460	3,646	2,793
No. 11	4,995	4,150	1,200	752	3,366	2,615
No. 12	4,668	4,025	2,010	1,420	3,339	2,665

*Average of 19 Samples

SURVEY SUMMARY OF BACTERIOLOGICAL DATA

COLIFORM ORGANISMS/100 ML*

TABLE B-10

October 18, 1969 through June 29,1970

Station Number	Maximum		Minimum		Average	
	Total	Fecal	Total	Fecal	Total	Fecal
No. 1	242,000	177,000	119,000	71,000	169,123	136,801
No. 2	168,000	88,000	57,000	45,000	81,054	71,311
No. 3	4,500	3,890	2,000	1,623	3,504	3,050
No. 4	5,000	3,596	2,300	1,555	3,004	2,745
No. 5	5,225	3,552	2,601	1,463	3,339	2,661
No. 6	4,990	3,467	2,331	1,500	3,109	2,699
No. 7	4,995	3,499	2,200	1,650	2,900	2,659
No. 8	5,300	3,600	2,100	1,900	3,000	2,595
No. 9	4,936	3,110	2,200	2,000	2,969	2,649
No. 10	5,644	3,934	2,373	1,765	2,929	2,223
No. 11	5,382	3,881	2,222	1,900	2,501	1,876
No. 12	5,566	3,465	2,321	1,872	2,498	1,789

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*Average of 81 Samples

SURVEY SUMMARY OF PHYSICAL DATA*

TABLE B-11

June 5 through October 11, 1969

Station Number	Maximum			Minimum			Average		
	Temp. (°C)	pH	D.O. (ppm)	Temp. (°C)	pH	D.O. (ppm)	Temp. (°C)	pH	D.O. (ppm)
No. 1	30	8.5	4.1	22	5.9	2.8	26	7.0	3.3
No. 2	32	8.9	8.8	18	6.6	5.9	26	7.9	7.2
No. 3	33	10.5	14.1	17	7.1	8.9	27	9.4	10.4
No. 4	33	10.6	14.1	17	8.3	9.0	27	9.1	10.5
No. 5	33	10.8	15.1	18	8.2	8.9	25	9.5	10.6
No. 6	33	10.8	13.1	18	8.2	18.2	26	9.5	10.4
No. 7	33	10.7	14.1	17	8.1	9.0	27	9.6	10.7
No. 8	33	10.8	14.1	18	8.1	9.2	25	9.7	10.7
No. 9	33	10.9	14.6	17	8.2	9.0	26	9.6	10.6
No. 10	33	11.0	14.5	18	8.3	9.2	26	9.8	10.5
No. 11	33	11.1	14.1	17	8.1	8.9	26	9.7	10.6
No. 12	33	11.3	14.2	17	7.9	9.0	27	9.7	10.5

---

*Average of 19 Samples

SURVEY SUMMARY OF PHYSICAL DATA*

TABLE B-12

October 18, 1969 through June 29, 1970

Station Number	Maximum			Minimum			Average		
	Temp. (°C)	pH	D.O. (ppm)	Temp. (°C)	pH	D.O. (ppm)	Temp. (°C)	pH	D.O. (°C)
No. 1	26.0	8.0	7.7	12.1	6.3	1.8	18.1	6.7	4.6
No. 2	25.0	8.1	9.0	9.0	5.9	6.1	18.1	7.3	7.9
No. 3	29.0	10.7	13.8	5.5	6.9	8.8	17.8	9.1	10.0
No. 4	28.5	10.5	14.1	5.1	6.8	8.9	17.6	9.3	10.6
No. 5	29.0	9.9	13.6	5.6	6.7	8.0	17.1	9.5	10.9
No. 6	28.7	10.4	12.6	6.1	6.6	8.9	18.0	10.0	11.8
No. 7	28.6	10.6	13.4	5.2	6.5	9.0	17.9	9.4	10.7
No. 8	27.8	10.2	12.9	6.0	7.0	8.9	17.1	9.0	10.3
No. 9	25.9	10.0	11.9	5.8	6.7	9.0	17.7	8.9	10.1
No. 10	25.0	10.3	12.1	6.0	9.1	9.9	17.9	9.9	11.0
No. 11	24.8	10.0	13.0	5.9	8.9	10.0	17.7	9.3	10.7
No. 12	24.6	10.5	13.4	6.1	9.2	9.8	17.6	9.9	10.9

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*Average of 81 Samples

APPENDIX C

Biological Survey of Upper Bayou Meto

Arkansas Pollution Control Commission

December, 1969

Introduction:

A short-term biological survey of Upper Bayou Meto was conducted to determine the general condition of the stream in early December, 1969. Plankton, benthos and coliform bacteria samples were taken, along with grab samples for chemical analysis, on each of three separate days. The results of these analyses are given in the attached tables.

Discussion:

Bayou Meto is a sluggish stream, meandering in a southeasterly direction from Jacksonville through intensely farmed flatlands to the Arkansas River. Sample points No. 1 and No. 2 are located above and below the effluent from the Jacksonville sewage treatment plant. The dramatic increase in total biomass and the increase in all the chemical parameters show considerable enrichment, but the degradation is by no means severe. While most of the organisms found at point No. 2 are generally considered pollution tolerant, several clean-water type plankton and benthos genera were found. The bacteria counts were not excessively high, with the averages for No. 1 and No. 2 being drastically reduced in comparison with the results obtained from similar tests in the spring of 1967.

The lower two points, located about 9 and 18 miles, respectively, below the Jacksonville STP show good recovery, with slight increases in several parameters between No. 3 and No. 4 being attributable to agricultural runoff. No odors were discernible in the stream at any time. Water temperatures at all points ranged between 5° and 7° C.

UPPER BAYOU METO STREAM SURVEY

CHEMICAL AND BACTERIOLOGICAL RESULTS

Station No. 1

Bayou Meto - West of Jacksonville City Limits - Above STP

Date Collected	1-A 12/2/69	1-B 12/3/69	1-C 12/4/69	Average	Average Spring '67
pH	6.5	6.5	6.6	6.5	6.2
Total Alkalinity, ppm	12	15	16	14.3	14
D.O., ppm	6.7	7.1	7.3	7.3	5.4
5-Day BOD, ppm	1.1	1.4	1.7	1.4	1.8
Total Solids, ppm	76	72	60	69	89
Chlorides, ppm	-	7.5	6.5	7.0	4
Total Coli. per 100 ml	490	240	220	320	1260
Fecal Coli. per 100 ml	24	66	40	43	-

UPPER BAYOU METO STREAM SURVEY

CHEMICAL AND BACTERIOLOGICAL RESULTS

Station No. 2

Bayou Meto at Highway 67 - 0.5 miles below Jacksonville STP

Date Collected	2-A 12/2/69	2-B 12/3/69	2-C 12/4/69	average	Average spring '67
pH	7.1	7.1	7.2	7.1	6.9
Total Alkalinity, ppm	26	28	30	28	24
D.O., ppm	8.0	7.9	7.9	7.9	5.8
5-Day BOD, ppm	8.0	6.7	7.4	7.3	5.8
Total Solids, ppm	135	126	122	127	186
Chloride, ppm	-	17.5	16.5	17.0	78
Total Coli. per 100 ml	2600	3400	7800	4600	43700
Fecal Coli. per 100 ml	230	260	920	470	-

UPPER BAYOU METO STREAM SURVEY

CHEMICAL AND BACTERIOLOGICAL RESULTS

Station No. 3

Bayou Meto at Interstate 40 - 9 miles below Jacksonville STP

Date Collected	3-A 12/2/69	3-B 12/3/69	3-C 12/4/69	Average
pH	6.9	6.9	6.9	6.9
Total Alkalinity, ppm	30	28	26	28
D.O., ppm	7.1	7.3	7.8	7.4
5-Day BOD, ppm	1.4	3.2	2.6	2.4
Total Solids, ppm	118	121	112	117
Chloride, ppm	-	16.5	15.0	15.7
Total coli. per 100 ml	230	430	330	330
Fecal Coli. per 100 ml	120	180	220	170

UPPER BAYOU METO STREAM SURVEY

CHEMICAL AND BACTERIOLOGICAL RESULTS

Station No. 4

Bayou Meto at Highway 31 - 18 miles below Jacksonville STP

	4-A	4-B	4-C	Average
Date collected	12/2/69	12/3/69	12/4/69	
pH	7.4	7.4	7.5	7.4
Total Alkalinity, ppm	53	57	58	56
D.O., ppm	6.8	8.7	8.7	8.0
5-Day BOD, ppm	2.3	3.9	3.4	3.2
Total Solids, ppm	169	155	152	158
Chloride, ppm	-	17.5	16.0	16.7
Total Coli. per 100 ml	310	630	630	520
Fecal Coli. per 100 ml	240	250	190	230

PLANKTON ORGANISMS

Sample Point	Scientific Name	Common Name	No./Liter	Sig.
No. 1	Trachelomonas	Flagellate	4,750	P
	Aphanizomenon	BGA	3,625	F
	Synedra	Diatom	2,125	C
	Diatoma	Diatom	1,625	C
	Euglena	Flagellate	875	P
	Stauroneis	Diatom	625	C
	Oscillatoria	BGA	500	P
	Pinnularia	Diatom	250	C
	Crucigenia	GA	250	?
	Eunotia	Diatom	125	?
	Nitzschia	Diatom	125	P
	Anacystis	BGA	125	P
	Brachionus	Rotifer	125	P
	Phacus	Flagellate	125	P
No. 2	Anacystis	BGA	3,382,000	P
	Bodo	Protozoan	1,770,000	P
	Chlamydomonas	Flagellate	1,396,000	P
	Mallomonas	Flagellate	255,000	P
	Scenedesmus	GA	67,000	F
	Ankistrodesmus	GA	13,000	C
	Actinosphaerium	Protozoan	5,000	?
	Aphanizomenon	BGA	5,000	F
	Trachelomonas	Flagellate	3,400	P
	Nitzschia	Diatom	2,200	P
	Agmenellum	BGA	1,900	?
	Synedra	Diatom	1,300	C
	Navicula	Diatom	1,100	C
	Pinnularia	Diatom	190	C
	Chromogaster	Rotifer	190	P
	Polyarthra	Rotifer	38	P
	Bosmina	Cladoceran	26	M
	Brachionus	Rotifer	6	P
	Cyclops	Copepod	6	F
No. 3	Bodo	Protozoan	36,000	P
	Scenedesmus	GA	25,200	F
	Melosira	Diatom	20,400	C
	Trachelomonas	Flagellate	18,800	P
	Synedra	Diatom	12,400	C
	Ankistrodesmus	GA	5,800	C
	Anacystis	BGA	5,400	P
	Navicula	Diatom	2,600	C
	Gomphosphaeria	BGA	1,900	F
	Euglena	Flagellate	1,000	P

Sample Point	Scientific Name	Common Name	No./Liter	Sig.
	Oocystis	GA	900	?
	Selenastrum	GA	900	?
	Pleurosigma	Diatom	500	P
	Crucigenia	GA	400	?
	Diatoma	Diatom	400	C
	Nitzschia	Diatom	250	P
	Tetrastrum	GA	125	?
	Difflugia	Protozoan	125	C
No. 4	Chlamydomonas	Flagellate	195,000	P
	Ankistrodesm	GA	155,000	C
	Scenedesmus	GA	71,000	F
	Trachelomonas	Flagellate	60,000	P
	Anacystis	BGA	46,000	P
	Melosira	Diatom	6,200	C
	Crucigenia	GA	5,800	?
	Euglena	Flagellate	4,600	P
	Navidula	Diatom	3,100	C
	Oscillatoria	BGA	1,700	P
	Pediastrum	GA	1,500	F
	Difflugia	Protozoan	1,100	C
	Agmenellum	BGA	1,000	?
	Nitzschia	Diatom	1,000	P
	Oocystis	GA	800	?
	Synedra	Diatom	800	C
	Phacus	Flagellate	600	P
	Tetraedron	GA	600	?
	Gomphosphaeria	BGA	600	F
	Asplanchna	Rotifer	400	P
	Gyrosigma	Diatom	400	?
	Spirulina	BGA	200	P
	Stauroneis	Diatom	200	C

BENTHIC ORGANISMS

Sample Point	Scientific Name	Common Name	No./Yd^2	Sig.
No. 1	Lymnaea	Pond snail	24	P
	Tendipes tentans	Midge larvae	9	P
	Helobdella stagnalis	Snail leech	6	M
	Sialis	Alderfly larvae	6	P
	Pisidium	Fingernail clam	12	P
	Tubifex	Tube worm	6	P
	Gammarus	Sideswimmer	39	C
	Astacidae	Crayfish (immature)	3	?
No. 2	Chaoborus	Phantom midge	48	F
	Dina fervida	Leech	27	P
	Gammarus	Sideswimmer	66	P
	Tendipes tentans	Midge larvae	6	P
	Pisidium	Fingernail clam	21	P
	Physa	Pouch snail	9	F
	Trichocorixa	Water boatman	54	C
	Cloeon	Mayfly nymph	6	C
	Berosus	Beetle larvae	3	C
	Asellus	Aquatic sowbug	3	P
	Astacidae	Crayfish (immature)	3	?
	Hydroporus	Diving beetle	3	M
No. 3	Pisidium	Fingernail clam	54	P
	Tubifex	Tube worm	6	P
	Tendipes tentans	Bloodworm	12	P
	Chaoborus	Phantom midge	3	F
	Chironomidae	Midge larvae	45	?
	Chironomidae	Midge larvae	27	?
No. 4	Cambarus	Crayfish	3	P
	Pisidium	Fingernail clam	3	P
	Hydrospsyche	Caddisworm	36	C
	Cloeon	Mayfly nymph	42	C
	Stenonema	Mayfly nymph	6	C
	Palaemonetes kadiakensis	Fairy shrimp	12	C
	Chironomidae	Midge larvae	24	?
	Gammarus	Sideswimmer	3	C

APPENDIX D

Biological Survey of Upper Bayou Meto

Arkansas Pollution Control Commission

December, 1970

Purpose:

A short-term biological survey of upper Bayou Meto was conducted during the week of December 7, 1970 for the purpose of assessing the general condition of the stream with particular reference to the Jacksonville sewage treatment plant and the Hercules Incorporated wastewater effluent which is discharged to the treatment plant.

This survey essentially duplicates one carried out in December, 1969, and is similar to portions of a larger scale survey done in the spring of 1967. This report will attempt to evaluate the biological condition of upper Bayou Meto in December, 1970 and compare it with the conditions found in 1969 and where possible, 1967.

Methods and Procedures:

Samples were taken at four points in the Bayou, one above the Jacksonville STP outfall, and the others at one-half, nine, and eighteen miles, respectively, below the outfall. These same points were sampled in 1969 and the two uppermost points were included in the 1967 survey.

Biological parameters, including plankton, benthos, and coliform bacteria, were sampled on three consecutive days, and chemical grab samples were taken on four consecutive days. All sampling and analyses were done according to procedures given in the Twelfth Edition of Standard Methods for the Examination of Water and Wastewater.

Bacteriological and chemical results are given in Tables 1 through 4. Results of plankton and benthos analyses are given in Appendix I.

Discussion:

As was the case in December 1969, the Bayou seems to be in generally good condition, with some degradation of water quality immediately below the Jacksonville sewage outfall, but with fairly rapid and complete recovery being achieved at the downstream locations.

If anything, the initial degradation just below the STP outfall was less severe in 1970. The total plankton population was less than two million per liter, while the 1969 population was nearly seven million per liter. Also, the biochemical oxygen demand was somewhat lower. Coliforms, however, were three to six times higher this year than in 1969, which is possibly due to the relatively milder weather experienced in the area this winter.

The two lower sample points were virtually identical in every respect when compared with 1969 data. In both cases there was a rather dramatic decrease in total plankton nine miles below the outfall, followed by a less severe increase eighteen miles below. This latter increase is undoubtedly due to increased fertility from runoff in this intensively farmed area. This conclusion is supported by the observed recovery at sample point 3, where good clean water organism associations, both planktonic and benthic, were found. At point 4, enrichment from runoff has apparently allowed the pollution-tolerant plankton to become abundant, but the benthic community remains very good, with some 90% of the organisms found belonging to genera usually considered intolerant of organic pollution.

In general, there seems to have been little change in Bayou Meto during the twelve months separating the 1969 and 1970 surveys. Both surveys indicate that the Bayou is doing an adequate job of assimilating the treated sewage from the Jacksonville plant and that the stream is recovering rather quickly from the degradation that does occur.

UPPER BAYOU METO STREAM SURVEY

CHEMICAL AND BACTERIOLOGICAL RESULTS

STATION NO. 1 - Dec. 1970

BAYOU METO - WEST OF JACKSONVILLE CITY LIMITS - ABOVE STP

Parameter*	Maximum	Minimum	Average	Average Dec. 1969	Average Spring 1967
pH	6.7	6.6	6.7	6.5	6.2
Temperature (°C)	8	7	7.5	-	-
Total Alkalinity	19	15	17	14.3	14
Chlorides	8.5	7.5	7.8	7.0	4.0
Dissolved Oxygen	6.9	5.5	6.2	7.3	5.4
B.O.D.	1.1	0.8	0.9	1.4	> 1.8
Total Solids	66	59	62	69	89
Dissolved Solids	58	50	54	-	-
Suspended Solids	10	6	8	-	-
Total Coliform	1900	780	1290	320	1260
Fecal Coliform	830	420	620	43	-

* All chemical parameters expressed as parts per million; coliforms as organisms per 100 ml.

UPPER BAYOU METO STREAM SURVEY

CHEMICAL AND BACTERIOLOGICAL RESULTS

STATION NO. 2 - Dec. 1970

BAYOU METO AT HIGHWAY 67 - 0.5 MILES BELOW JACKSONVILLE STP

Parameter*	Maximum	Minimum	Average	Average Dec. 1969	Average Spring 1967
pH	7	6.7	6.9	7.1	6.7
Temperature (°C)	9	6	7.5	-	-
Total Alkalinity	37	31	34	28	24
Chlorides	57	54	55	17.0	18
Dissolved Oxygen	7.4	5.7	6.3	7.9	5.8
B.O.D.	5.7	3.9	4.7	>7.3	>5.8
Total Solids	193	147	172	127	186
Dissolved Solids	164	157	160†	-	-
Suspended Solids	29	3	21†	-	-
Total Coliform	22,000	8400	15,100†	4600†	43,700†
Fecal Coliform	4,400	990	2,630†	470†	-

* All chemical parameters expressed as parts per million; coliforms as organisms per 100 ml.

†Average three samples

UPPER BAYOU METO STREAM SURVEY

CHEMICAL AND BACTERIOLOGICAL RESULTS

STATION NO. 3 - Dec. 1970

BAYOU METO AT INTERSTATE 40 - 9 MILES BELOW JACKSONVILLE STP

Parameter*	Maximum	Minimum	Average	Average Dec. 1969
pH	6.9	6.8	6.9	6.9
Temperature (°C)	10	7	8	-
Total Alkalinity	31	28	30	28
Chlorides	50.5	48	49	15.7
Dissolved Oxygen	7.3	5.6	6.3	7.4
B.O.D.	1.9	0.9	1.2	2.4
Total Solids	164	147	159	117
Dissolved Solids	159	122	147	-
Suspended Solids	28	3	12	-
Total Coliform	500	180	390	330
Fecal Coliform	240	110	180	170

* All chemical parameters expressed as parts per million; coliforms as organisms per 100 ml.

UPPER BAYOU METO STREAM SURVEY

CHEMICAL AND BACTERIOLOGICAL RESULTS

STATION NO. 4 - Dec. 1970

BAYOU METO AT HIGHWAY 31 - 18 MILES BELOW JACKSONVILLE STP

Parameter*	Maximum	Minimum	Average	Average Dec. 1969
pH	7.3	7.1	7.2	7.4
Temperature (°C)	11	7	8	-
Total Alkalinity	50	35	44	56
Chlorides	36	30.5	34	16.7
Dissolved Oxygen	9.6	8.9	9.4	8.0
B.O.D.	3.2	0.9	2.3	3.2
Total Solids	191	156	168	158
Dissolved Solids	154	122	143	-
Suspended Solids	42	16	24	-
Total Coliform	830	1300	1110	520
Fecal Coliform	310	820	530	230

* All chemical parameters expressed as parts per million; coliforms as organisms per 100 ml.

APPENDIX I

PLANKTON ORGANISMS

UPPER BAYOU METO SURVEY - Dec. 1970

Sample Point	Scientific Name	Common Name	#/Liter
#1	Ankistrodesmus	GA	17,300
	Aphanizomenon	BGA	14,700
	Oscillatoria	BGA	12,600
	Trachelomonas	Flagellate	4,900
	Navicula	Diatom	4,000
	Anacystis	BGA	3,500
	Anabaena	BGA	3,300
	Scenedesmus	GA	1,900
	Euglena	Flagellate	1,600
	Diatoma	Diatom	1,400
	Nitzschia	Diatom	1,200
	Synedra	Diatom	1,200
	Phacus	Flagellate	700
	Gymnodinium	Flagellate	500
	Mallomonas	Flagellate	500
	Vorticella	Protozoan	500
	Golenkinia	GA	200
#2	Golenkinia	GA	787,700
	Chlorococcus	GA	636,500
	Anacystis	BGA	113,900
	Chlorella	GA	78,400
	Scenedesmus	GA	42,900
	Micractinium	GA	39,500
	Agmenellum	BGA	33,600
	Oocystis	GA	28,000
	Navicula	Diatom	16,800
	Gymnostomata	Protozoan	9,300
	Ankistrodesmus	GA	5,600
	Chlamydomonas	Flagellate	3,700
	Coelosphaerium	BGA	3,700
	Nitzschia	Diatom	3,700
	Ciliata	Protozoan	3,700
	Pediastrum	GA	1,900
	Chrysococcus	Flagellate	1,900
	Synedra	Diatom	1,900
	Brachionus	Rotifer	1,900
	Schroederia	GA	1,900
	Tetraedron	GA	1,900
	Mallomonas	Flagellate	1,900
	Actinastrum	GA	1,900
	Stephanodiscus	Diatom	1,900
	Arthrodesmus	GA	1,900

PLANKTON ORGANISMS
Cont.

Sample Point	Scientific Name	Common Name	#/Liter
#3	Navicula	Diatom	53,900
	Ankistrodesmus	GA	18,200
	Trachelomonas	Flagellate	10,500
	Golenkinia	GA	9,300
	Anacystis	BGA	8,900
	Scenedesmus	GA	7,200
	Nitzschia	Diatom	5,400
	Tetraspora	GA	4,400
	Diatoma	Diatom	4,200
	Pleurosigma	Diatom	4,000
	Synedra	GA	3,700
	Aphanizomenon	BGA	3,300
	Oocystis	GA	2,600
	Crucigenia	GA	2,100
	Coelastrum	GA	1,600
	Mallomonas	Flagellate	700
	Melosira	Diatom	700
	Euglena	Flagellate	700
	Vorticella	Protozoan	500
	Pediastrum	GA	500
	Oscillatoria	BGA	500
	Staurastrum	GA	500
	Selenastrum	GA	500
	Difflugia	Protozoan	500
	Nauplius	Copepod	200
	Phacus	Flagellate	200
#4	Anacystis	BGA	200,000
	Phacus	Flagellate	155,400
	Scenedesmus	GA	121,800
	Ankistrodesmus	GA	37,800
	Navicula	Diatom	35,000
	Aphanizomenon	BGA	33,600
	Oscillatoria	BGA	21,000
	Pleurosigma	Diatom	13,100
	Stephanodiscus	Diatom	12,600
	Agmenellum	BGA	11,700
	Chrysococcus	Flagellate	10,300
	Chlorococcus	GA	8,400
	Coelosphaerium	BGA	4,700
	Actinastrum	GA	4,200
	Nitzschia	Diatom	2,800

PLANKTON ORGANISMS
Cont.

Sample Point	Scientific Name	Common Name	#/Liter
#4	Synedra	Diatom	2,800
	Gymnostomata	Protozoan	2,800
	Trachelomonas	Flagellate	2,800
	Pediastrum	GA	2,300

GA - Green Algae
BGA - Blue Green Algae

BENTHIC ORGANISMS

UPPER BAYOU METO SURVEY - DEC., 1970

Sample Point	Scientific Name	Common Name	#./Yd^2
No. 1	Gammarus	Sideswimmer	102
	Tendipes tentans	Bloodworm	147
	Pisidium	Fingernail clam	6
	Physa	Pouch snail	3
	Viviparus	Snail	12
	Ischnura	Damselfly larvae	3
	Dytiscidae	Diving Beetle larvae	24
	Helobdella	Snail Leech	3
	Erythrodiplax	Dragonfly larvae	3
	Taeniopteryx	Stonefly larvae	3
No. 2	Gammarus	Sideswimmer	663
	Asellus	Aquatic sowbug	147
	Tendipes tentans	Bloodworm	147
	Physa	Pouch snail	30
	Ischnura	Damselfly nymph	21
	Pisidium	Fingernail clam	9
	Helobdella stagnalis	Snail leech	9
	Peltodytes	Crawling Water beetle	6
	Chaoborus	Phantom midge	6
	Trichocorixa	Water Boatman	3
	Astacidae	Crayfish	3
	Somatochlora	Dragonfly nymph	3
No. 3	Gammarus	Sideswimmer	75
	Hydropsyche	Caddisfly larvae	39
	Pisidium	Fingernail clam	23
	Tendipes tentans	Bloodworm	14
	Caenis	Mayfly nymph	11
	Hyponeura	Damselfly larvae	2
	Cambarus	Crayfish	9
	Simulium	Blackfly larvae	6
	Corixinae	Water Boatman	6
	Musculium	Fingernail clam	4
	Dytiscidae	Diving Beetle larvae	2
	Helisoma	Snail	2
	Palaemonetes kadiakensis	Fairy shrimp	2
	Macrobdella	Leech	3
	Ophiogomphus	Dragonfly larvae	1
	Micromyia	Clam	1

Sample Point	Scientific Name	Common Name	#/Yd^2
No. 4	Hydropsyche	Caddisfly larvae	87
	Gammarus	Sideswimmer	63
	Cloeon	Mayfly nymph	18
	Stenonema	Mayfly nymph	15
	Tubifex	Sludgeworm	9
	Tendipes tentans	Bloodworm	7
	Lumbricidae	Aquatic earthworm	7
	Palaemonetes kadiakensis	Fairy shrimp	6

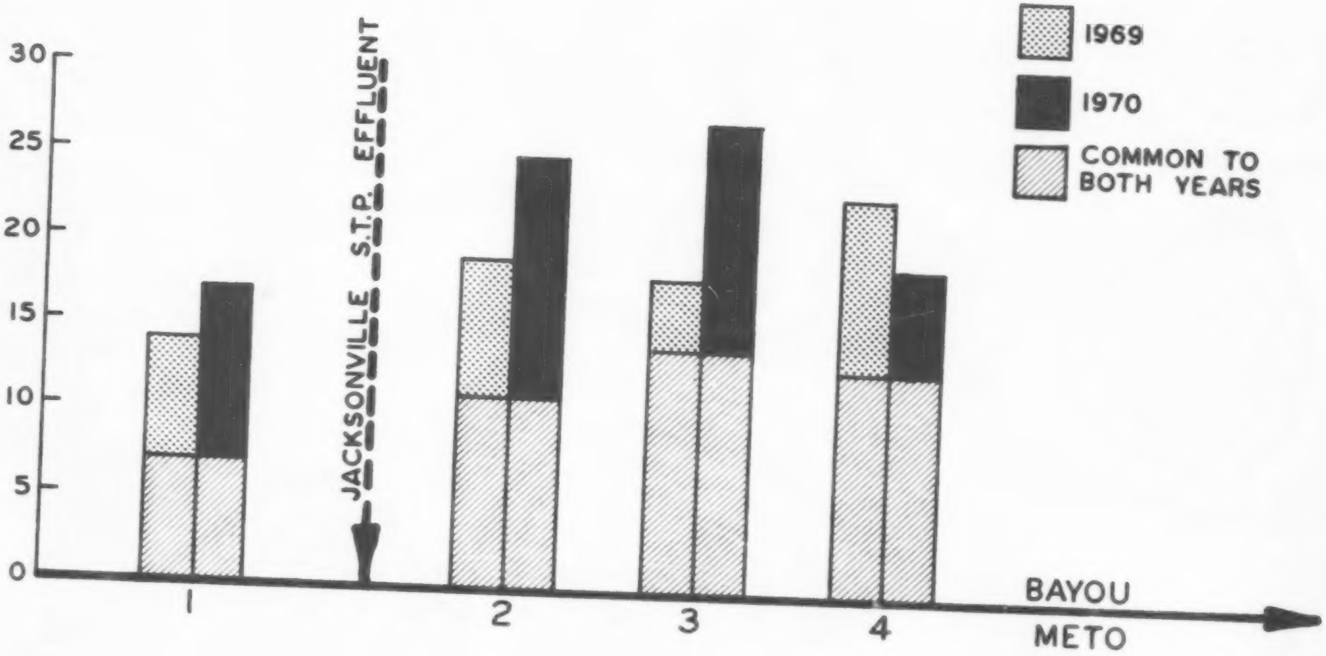

TABLE I. A COMPARISON OF TOTAL PLANKTON GENERA IN BAYOU METO IN 1969 AND 1970, SHOWING THE NUMBER COMMON TO BOTH YEARS.

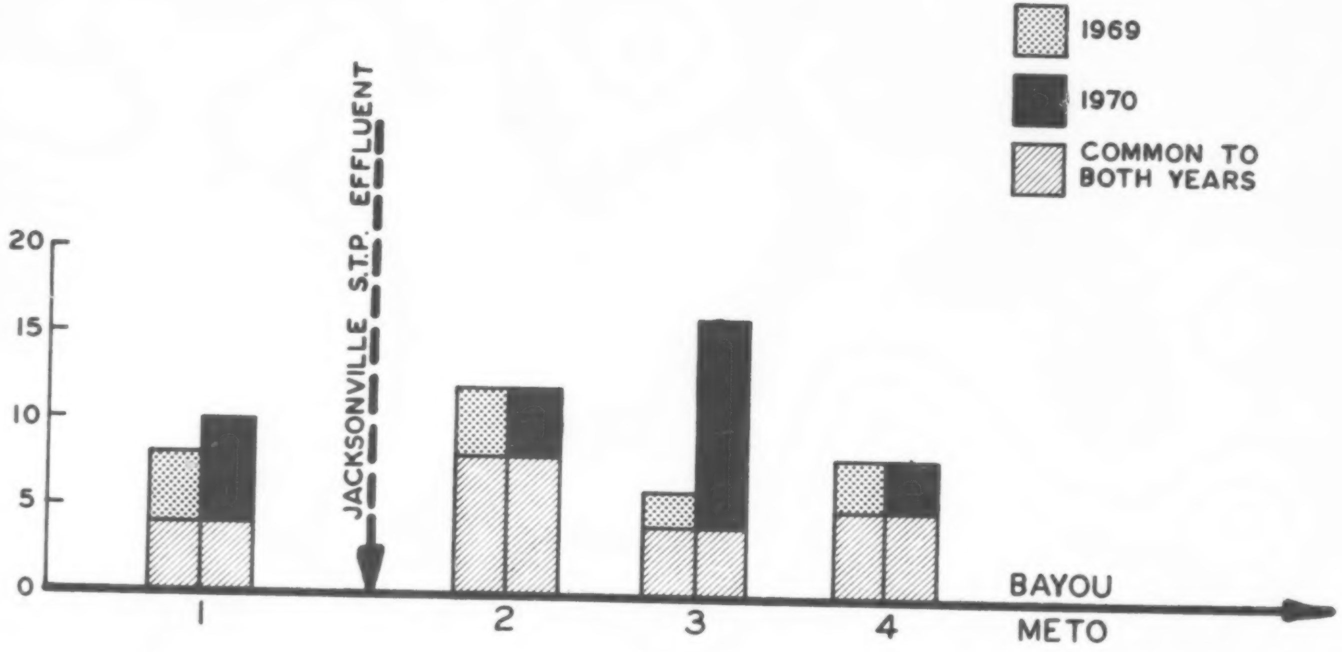

TABLE II. A COMPARISON OF TOTAL BENTHIC GENERA IN BAYOU METO IN 1969 AND 1970, SHOWING THE NUMBER COMMON TO BOTH YEARS.

1 Accession Number **W**	2 Subject Field & Group 05D	**SELECTED WATER RESOURCES ABSTRACTS** **INPUT TRANSACTION FORM**

5 *Organization*

City of Jacksonville, Arkansas

6 *Title* Biological Treatment of Chlorophenolic Wastes --
The Demonstration of a Facility for the Biological Treatment of a Complex Chlorophenolic Waste

10 *Author(s)*

Albert E. Sidwell Ph.D

16 *Project Designation*

12130EGK (11060EGK)

21 *Note*

22 *Citation*

23 *Descriptors (Starred First)*

Biological Treatment*, Aeration

25 *Identifiers (Starred First)*

Chlorophenol*, Lagoons, Plankton Organisms

27 *Abstract*

Installation of a completely stirred aeration lagoon between an existing conventional sewage treatment plant and existing stabilization ponds avoided hydraulic overloading of the former and reduced BOD loading of the latter. Joint treatment of domestic sewage and an industrial waste having high BOD and chlorophenols was facilitated. The study confirmed earlier findings that the organisms present in domestic sewage readily destroy complex chlorophenols and related materials. Glycolates and acetates contributing to the high BOD of the industrial waste were also readily oxidized biologically. High sodium chloride levels in the treated mixed waste did not adversely effect biological activity. Joint treatment of the complex chlorophenolic wastes combined with normal sewage gave rise to biological data which did not differ in any significant manner from that to be expected in a similar system receiving only normal sewage.

An historical background of the problem at Jacksonville, Arkansas; design and construction information, and the chemical and biological data resulting from the system study are presented.

This report was submitted in partial fulfillment of Project No. 12130 EGK between the Water Quality Office, Environmental Protection Agency and the City of Jacksonville, Arkansas.

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